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STUDIES OF GASTROPODA

III. ON ORTHOGENETIC VARIATION IN GASTROPODA<sup>1</sup>

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ORTHOGENETIC variation may be defined as progressive variation along definite or determinate lines, whether such variation is along the line of increasing or decreasing complexity; i. e., aggradational or degradational. In the first place orthogenetic variation is *ontogenetic*; i. e., the successive changes which the individual undergoes in its transformation from embryo to adult follow each other in definite succession, the changes appearing step by step. When we are convinced that the changes seen in the development of the individual are reminiscent of the changes passed through by its successive ancestors, it becomes apparent that *phylogenetic* variation is also orthogenetic, or along definitely determinable lines.

It has been the general custom to test the validity of the recapitulation theory by the embryological method; i. e., the comparableness of the changes which the individual undergoes during its embryonic period, to the adults of more primitive types. Usually the comparison has been with adults of existing types, since in most cases these alone were available for comparison. It is no wonder, then, that such comparisons have led to innumerable errors, if not absurdities, which have placed the recapitulation

<sup>1</sup> The previous numbers of these "studies" appeared in the *American Naturalist* as follows: No. I, vol. XXXVI, no. 432, pp. 917-945, Dec. 1902; No. II, *Fulgur* and *Sycotypus*, vol. XXXVII, no. 440, pp. 515-539, Aug. 1903.

<sup>2</sup> Investigations carried on by the aid of a grant from the Hermann Fund of the council of the Scientific Alliance of the city of New York.

theory in an evil light, and awakened in the minds of many serious investigators doubts as to the validity of the deductions based upon this doctrine. When, however, the entire life history of the individual is considered, instead of only the embryonic period, and when the successive stages of epembryonic development are compared with the adult characters of related types in immediately preceding geologic periods, it will be found that the fundamental principle of recapitulation is sound, and that the individuals do repeat in their own epembryonic development the characters of their immediate ancestors.

One of the great mistakes made by the majority of systematists is the disregard of the immature stages of development; i. e., the stages between the embryonic and adult. This is notably the case among writers on recent mollusks, who either ignore the early stages entirely in their specific description or give them the briefest notice. And yet it is in these early stages that we find the key to the affinities of a given species with others of its kind, in the present and in past faunas, more often and more surely than in the adult characters. To classify by adult characters only is to neglect the nearest and most obvious method for the ascertainment of the line of descent of the species in question; and, further, it is to leave out of consideration the inevitable similarity produced in the aspect of adult types of different origins, by a loss of the characters distinctive of their respective ancestors and of their younger stages. The classification into one family of all bald headed men of the same age would not be more illogical than some of the classifications of phylogerontic mollusks in vogue today,—classifications based wholly on adult characters. Agassiz long ago called attention to the need of considering the stages between the embryo and adult, as the following extracts will show.

"Embryologists have generally considered their work as completed when they have traced the new being to a point at which it resembles somewhat any of the members of the natural group to which it belongs. The process by which the gradual completion of the whole frame is attained has been assumed to be of little interest, hardly deserving the careful scrutiny of the embryologist; while the zoologist has also overlooked, or regarded as of little importance, the differences which still distinguish the young from

the adult, even after its typical characters are perfectly distinct."<sup>1</sup> And again: "...I would say to all young students of Embryology that their next aim should be to study those intermediate phases in the life of a young animal, when, having already acquired independent existence, it has not yet reached the condition of the adult. Here lies an inexhaustible mine of valuable information unappreciated, from which...may be gathered the evidence for the solution of the most perplexing problems of our science."<sup>2</sup>

AVAILABILITY OF THE MOLLUSCA FOR THE STUDY OF  
DEVELOPMENTAL STAGES

Of all classes of organisms, the mollusks are perhaps the best adapted for the study of ontogenetic stages between the embryo and the adult, since all these stages are preserved as a permanent record in the form of the shell. Such a record cannot, of course, be obtained from the soft parts, where a number of individuals are necessary to represent the principal stages. Moreover, a certain step in development may be very definitely indicated in the form and sculpture of the shell, and yet be entirely unrecognizable in the soft parts. Not only, then, is the shell a permanent record of the changes, but it is also a more delicate register of advancement than is afforded by the soft parts. In other groups of organisms, the record is seldom so complete, though brachiopods and corals retain, in perfect specimens, all the earlier stages. Other organisms, however, such as the echinoderms and vertebrates, preserve in their hard parts only the record of the stage at which the animals die, since these hard parts undergo individually constant changes from youth to maturity.

Among the mollusks, the gastropods and cephalopods are the most satisfactory for ontogenetic investigations, since in them the early stages are not only well preserved, but there are also a large number of characters the progressive variations of which may be studied. In many respects gastropod shells are the simpler to study, because the greater parts of the whorls are freely exposed

<sup>1</sup> Agassiz, *Methods of Study in Natural History*, Chapter XVI.

<sup>2</sup> *Ibid.*, Chapter XV.

and open to observation, whereas in the coiled cephalopod shells the outer whorls must be removed before a satisfactory view of the inner ones can be obtained. Despite this fact, the study of shell ontogeny has been mostly confined to the cephalopods, especially to the highly complex and often richly ornamented ammonite shells; and this can hardly be wondered at, when we consider their number, and the high degree of diversity found in this group of organisms.

#### ORTHOGENESIS IN THE ONTOGENETIC DEVELOPMENT OF GASTROPODS

The individual development of gastropod shells always follows one of a small number of lines of variation. Leaving aside color markings, which have been somewhat fully discussed by the Countess von Linden,<sup>1</sup> we may devote this discussion to the changes in form and ornamentation. At the outset, however, we must note that in every perfect shell there are two parts to consider; namely, the protoconch and the conch. These may be continuous with each other, in which case the features of the protoconch merge into those of the conch; or they may be discontinuous, when the protoconch features end abruptly and the conch features begin as abruptly. (See *Studies of Gastropoda*, I, fig. 5.)

The form of the gastropod shell is manifold, but the types are few. Primitive types always begin with rounded whorls free from all ornamentation. The coiling of the whorls at first is in a sufficiently loose manner to produce a hollow axis, opening below in an umbilicus. Even in types in which the anterior end of the adult is produced into a canal — as in *Fulgur*, *Buccinum*, *Fasciolaria*, etc. — the earliest protoconch stage has been found to show the umbilicated round-whorled condition (*Studies of Gastropoda* I, fig. 3). This condition may be accompanied by various modifications in the amount of embracing of the succeeding whorls. In all cases a moderate amount of embracing by the succeeding whorls seems to be the simplest condition, although it must be borne

<sup>1</sup> Die Entwicklung der Skulptur und der Zeichnung bei den Gehäuse-schnecken des Meeres. *Zeitschr. f. wissenschaft. Zoologie*, LXI, p. 261.



in mind that a difference may here be found between protoconch and conch. When the whorls embrace but slightly, a deep suture is produced between them. In this case the spire also is a slender one, as is shown in so many primitive fusoid shells (Studies I, fig. 6). As the amount of embracing increases, the suture becomes less strongly depressed, and the spire takes on an ever greater apical angle. The amount of embracing may increase until the suture is found at the ambitus of the preceding whorl (Studies II, fig. 13). Beyond this, the embracing is only carried in the old age of the individual of normal types or in specialized types, generally the members of a phylogerontic series.<sup>1</sup>

In a large number of types, the amount of embracing by the whorl remains practically the same throughout life, thus giving the spire a uniform angle. In others, again, and perhaps in the majority of specialized types, the embracing is at first less, but slowly increases in amount with each succeeding whorl in the later stages (Fig. 1).

Even in degradational types, where the embracing of the adult shell is in extreme excess of that of the normal adult type, the amount of embracing increases regularly from its first appearance to the completion of the growth.

There is another extreme found in phylogerontic members of a certain group of Gastropoda and so far observed in the non-canaliculate types only; namely, the loss of the power to coil, due to the equalization of the rate of increase in all portions of the shell (Studies I, figs. 14 and 15). This results in a looser coiling or complete straightness of the final portion of the last whorl, and may or may not be accomplished by an increase in the diameter of the whorl. Ontogenetically this is often expressed by a progressive loosening of the coil, though there are various degrees of abruptness, some coils becoming gradually straightened, while in other types this straightening appears very abruptly. As will be shown presently, the loss of power to coil and the excessive spread-

<sup>1</sup> The nomenclature of stages in development, devised by Hyatt, Buchmann, Bather and others, is for ontogenetic stages as follows: *neponic*, babyhood; *neanic*, youthful or adolescent; *ephebic*, adult; *gerontic*, old age or senile. Corresponding stages in phylogenesis are designated by the prefix *phylo*, but the term *phylogerontic*, or racial old age, is the only one in common use.

ing of the whorl are generally accompanied by the loss, or at least a modification, of the ornamentation.

A second important type of modification of form in ontogeny is the angulation of the whorls. This begins as a slight depression in the curvature of the upper or shoulder portion of the whorl, and a similar depression of the lower or body portion. Thus a faint angulation appears in the ambital portion of the whorl, which usually occurs where the whorl is marked by the first or most pronounced of the spirals. From a faint beginning, the angle increases in sharpness, and the depression of the shoulder surface and body surface increases, until the whorl consists of two perfectly flat or even slightly concave surfaces separated by a sharp angle (Fig. 2). Where the angulation appears late in the ontogeny, generally about an equal flat space is shown above and below the angle (Fig. 8). When it appears early, the later whorls generally embrace the preceding more strongly, thus decreasing the space below the angle, until in extreme cases this lower space has entirely disappeared, the suture of the succeeding whorl being at the angle (compare Fig. 5 with the younger portion of another individual enlarged in Fig. 2). This produces a continuous slope of the spire, which may vary, in different types, from nearly horizontal as in *Conus*, where the shoulder makes a right angle with the axis of coiling of the shell, to nearly vertical as in some *Turritellas* and *Cerithium*, where the shoulder makes a very acute angle with the axis of coiling, and the ambital angulation is far down on the shell. In all such cases, however, it is the rule that the earlier whorls are less closely coiled, so that in the young spire the flattened body of the whorl, below the angulation, becomes visible (Fig. 2). This is true even of such highly specialized types as *Conus*, where the shoulders alone of all the later whorls are visible; for the young whorls here project commonly above the general surface, showing a more steeply sloping shoulder, and generally exhibiting a portion of the whorl below the angulation, though this portion may be the merest fraction of the whorl. Rarely has acceleration gone so far that the shell begins with an angle and the whorls embrace up to the angle. The norm of the embracing, as in the slope of the shoulder, seems to be that which approaches most nearly to the round-whorled condition; i. e., an equal exhibition of flattened

shoulder and body, and approximately an angle of  $45^\circ$  between the shoulder and the axis of coiling. From this the progressive change is to a steeper shoulder in one series and to a flatter shoulder in the other. Similarly, the partial embrace of the whorls seems to be the norm, from which variation on one hand is in the direction of more pronounced embracing, carried to excess in phylogerontic

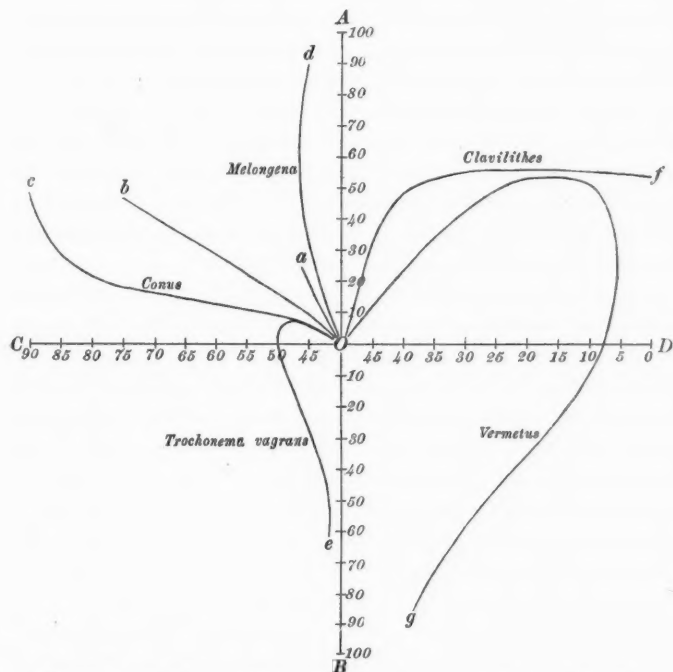


Diagram 1.—To illustrate the development of various types of gastropod shells, as explained in the text.

types, and in the other to a gradual loss of power to coil, which also terminates in a phylogerontic condition. These relationships may be represented in the following manner (Diagram 1).

The ambitus of the whorl, or the point of greatest convexity, is taken as the center of the whorl. The line  $O - A$  represents progressive increase in embracing, from zero at  $O$  to 50% at the ambitus, and to complete overlapping and concealing of the pre-

ceding whorl at *A* (100%). *O — B* represents progressive loss of coiling power to straight conditions at *B*; *O — C*, increasing horizontality of shoulder from round at *O* to 45° and thence to horizontal or 90° with reference to the axis of coiling. *O — D* in the same way represents increasing verticality from 45° to 0°, or parallelism with reference to the axis of coiling, at *D*.

A simple round whorled shell in which the whorls do not embrace throughout life (primitive *Fusus*) would be represented by the point *O*. One in which a slight amount of embracing occurs, but no change in outline of whorl, is represented by a line on *O — A*, the length of which marks the percentage of embracing up to 50 at the ambitus or more if the whorls overlap. The line may not start at *O* but higher up, the earlier whorls showing some embracing. The line *O — a* represents the life of a shell in which the whorls gradually change to angular (45°) and the embracing increases up to 25% or half way to the ambitus.

*O — b* represents a shell with gradual increase of embracing of whorls to ambitus, and flattening to 75° with reference to the axis of coiling, as in some *Fulgurs*. *O — c* represents a more rapid flattening than increase in embracing, as in *Conus*; *O — d* a gradual increase in embracing to below the ambitus, while at the same time the whorls are flattened to a shoulder of 45°. Then the embracing continues to the ambitus, beyond which, with increasing embracing, the whorls lose their angularity. This is seen in *Melongena*. In *Clavilithes*, represented by *O — f*, embracing increases to the ambitus, after which the whorls become quickly flattened vertically to 0°. *Vermetus* is represented by *O — g*, in which increasing embracing and flattening to 10° or less represents the *Turritella* stage, after which a loss of the embracing finally brings us to the loose coiling type with a return to round whorled condition. Similar changes are seen in *Trohonema vagrans* (Studies I, fig. 15) where angular embracing whorls are succeeded by loose rounded ones.

#### ORNAMENTATION OF THE WHORLS.

As already shown in the first of these studies (*Am. Nat.*, XXXVI, p. 930) the ornamentation of the whorl consists of ribs, spirals,

tubercular keel, and spines. Of these, so far as ascertained, the ribs generally appear first, though in a group of early gastropods in which ribs are never developed in the adult, spirals may be well developed. The point of importance, however, is not the relative time of appearance, but the mode of development of each, and their influence upon each other when they occur together. Where the development is complete, the ribs are at first faint vertical ridges upon a rounded whorl, enlarging gradually until they are strong, rounded, elevated ridges extending from suture to suture, with their greatest prominence at the ambitus of the whorl (Figs. 16-17). From being at first rather distant, they may increase in breadth until they are separated only by a depressed line. With the appearance of the ambital angulation, the ribs become fainter towards the sutures, while at the same time they become more pronounced upon the ambitus. Eventually the ribs disappear entirely from the shoulders, disappearing at the same time or somewhat later from the body of the whorl below the shoulder angle. Then only a regular row of tubercles remains behind, each tubercle being the concentrated essence of the ribs of the earlier stages (Studies II, fig. 10). Throughout, this process of metamorphosis is a regular progression, though in some (i. e., accelerated) shells it occupies a smaller number of whorls than in others. Up to this point there is uniformity in development of all ribbed shells with angular whorls following upon rounded ones. Beyond this point there is a divergence; along one line the tubercles gradually broaden and become confluent into a keel (Studies II, fig. 12) which forms a prominent and persistent character, disappearing only in old age types when the shell becomes rounded; along another line the keel, if it comes into existence quickly disappears, when the shell becomes rounded in outline. Upon this a new type of ornamentation, the spine, appears. This will be more fully discussed below.

*The spirals.*—These are continuous and persistent folds in the shell substance, caused by a slight emargination in the lip of the shell. This emargination corresponds to a faint wrinkle in the mantle when withdrawn, the growth of that organ being a more rapid one than is commensurate with the increase in diameter of the whorl. Thus while when expanded, the mantle is smooth,

when withdrawn it must be folded into minute wrinkles to become accommodated to the smaller space. That these spirals are generally visible only as emarginations on the margin of the lip, indicates that only the outer portion of the mantle is affected by this excess of growth. If other parts of the mantle are affected, lirae result on the inside of the outer lip and plications on the columellar lip.

The order of appearance of the spirals is a very regular and progressive one. In simple or primitive shells a single spiral makes its appearance at the ambitus, followed in most cases successively by spirals above and below. A partial exception to this rule is found in types in which a certain number of stages have been dropped out between the protoconch and conch and hence the conch does not begin at the beginning (Studies I, fig. 5) but at a stage normally belonging later in the ontogeny. Thus in *Fusus*, *Latirus*, *Semifusus* and certain *Murices* the conch begins abruptly with rounded ribs and three or more spirals. Such dropping out of early stages is however entirely in conformity with the general progress of development and is itself progressive, or orthogenetic. It belongs however in the category of phyletic orthogenesis.

At whatever stage of development the shell begins, that development is thereafter progressive. Thus in a large number of forms, if the shell begins with three spirals, the fourth, fifth and later spirals appear progressively above the upper, and below the lower one. If the whorls become asymmetrical, with continued growth, as is the case in the majority of shells where the lower (anterior) portion is either drawn out into a spindle and canal, or is flattened and depressed, the development of the spirals will be unequally distributed. Thus in shells with a spindle, three or four spirals may appear successively below, while only one appears above the ambitus.

In some cases as in *Goniobasis*, certain *Melantias* etc., the third and later spirals appear as intercalations between the first two. In this respect they resemble the secondary spirals to which indeed they may be closely allied. They however quickly reach the size and other characters of the two first spirals with which they appear to form the primary series (Figs. 13 and 18). Additional intercalated spirals with the habitat of the secondary spirals appear between them at a later period.

The manner of appearance of the spirals must be regarded as a consequence of the rate of growth of the mantle. Considering that the first two spirals are the result of the first two folds into which the mantle border is thrown on retraction, and assuming that the position of these folds is a permanent one as appears indeed to be unquestionable from the continuity and regularity of the spirals, we perceive that if the mantle border grows more rapidly above and below the original folds than between them, the new spirals will appear respectively above and below the first two. If on the other hand the mantle grows fastest between the two original folds, the corresponding spirals will diverge and new ones appear between them. This is the case in the formation of the secondary spirals in the Fusidae and other forms. The question may well be asked if these two modes of appearance of the early spirals do not represent two lines of development originating independently in various genetic series and producing end-members, which, within the same series, are indistinguishable in their adult characters. If, on the other hand, we regard intercalation as the method of appearance of secondary and later spirals, then Gonio-basis and the Melanias and other types which show intercalation after the appearance of the first two spirals, must be considered as highly specialized and accelerated types.

When the full number of primary spirals has appeared, or in accelerated shells at an earlier period, intercalated spirals appear, beginning in the broadest interspaces. In fusoid shells this intercalation begins on the spindle, where expansion is most pronounced. Secondary spirals are followed by tertiary ones, and sometimes by spirals of a higher order, all being intercalations between the primary ones. The first spiral generally marks the point at which the ambital angulation occurs. A strengthening of this spiral is, indeed, often the first indication of approaching angularity, and in some cases the change of whorl does not progress beyond this point. When the central spiral continues to increase in size, after the ribs have been reduced to nodules, the form of these nodules will be influenced by the spiral, so that instead of knobs they will be elongated, rounded, and flattened nodes. Such a condition is well shown in *Fusus distans*. This condition often ends in complete confluence and the formation of a keel (*Sycotypus canaliculatus*).



*Spines.*—These are of two kinds in gastropods. In a number of phylogerontic platyceroids they consist of tubular prolongations from the surface of the shell at irregular intervals, and appear to be of little phyletic significance. The other, more important type represents a periodic emargination in the lip of the shell (Figs. 3-4, 7-8). That the periodicity of this spine formation is connected with the regular recurrence of the reproductive period, may be assumed for types in which these spines appear late in the ontogeny; but not for those in which they appear early. Direct observations in this field seem to be wanting, however. The rate of growth of the shell during the interval between such periods of spine formation determines the number of spines upon a volution. As has been shown for *Fulgur* (Studies II, p. 534) the number of periods in progressive types decreases as the shell increases in size, thus showing that the amount of growth between resting stages (i. e., spine forming stages) increases at a rate faster than the rate of increase in the size of the shell. This may of course also be interpreted as a lengthening of the time interval between resting stages, or possibly between the reproductive periods. In some forms the decrease in the number of spine periods to the whorl is a rapid one, as in *Fulgur eliceans*, where it is 12, 9, and 6 respectively for the 5th, 6th, and 7th whorl, whereas the decrease is 14, 13, 12, or 13, 12, 11 for the same whorls in *F. carica*. In *Murex (Rhino-canthus) brandaris*, on the other hand, it is 6, 6, and 7 for the 5th, 6th and 7th whorl respectively, thus showing a shortening of the growth periods. In the majority of Murices, however, the number of periods has been reduced to three for all whorls. In *Ranella* the number of resting stages as expressed by the varices has been reduced to two for each whorl.

The simplest spine is that found in *Fulgur*. It has been quite fully described in a preceding number of these "Studies" (II) and the only point that needs to be emphasized in this connection is the gradual appearance of the spine in the ontogeny of the individual. This is not noticeable in *Fulgur carica* or other accelerated types of *Fulgur*, as fully discussed in the papers referred to, but is well shown in the more primitive Miocene types (e. g., *F. tritonis*, fig. 7). Here the spines appear on a faintly keeled or smooth shell, and at first are in the form of the merest faint spinelet, scarcely



noticeable, though recognizable to the touch as a faint protuberance. From this beginning the spine grows, period by period, until it has become of the normal adult dimensions. In some forms the spine continues to grow throughout life, giving us the enormous spines of *Fulgur candelabrum*.

Where a second row of spines appears this always comes in later than the first, though acceleration may tend to shorten up the interval, or even by dropping out the earliest stages produce a type in which more than one spine appears at the beginning of the conch stage. *Tudicula* is a good example of normal succession in the appearance of spine rows. In the Miocene *T. rusticula*, only a single row of fulguroid spines appears on the ambital angulation (Fig. 3). In *T. bispinosa* sp. nov.<sup>1</sup> (Figs. 1, 3 and 4) the spines of the first row increase in size, progressively though slowly while a second row of spines makes its appearance lower down on the body whorl, after the first has been in existence for a considerable number of volutions. This second row begins with the merest elevation, scarcely visible though noticeable to the touch (Figs. 1 and 3). From this beginning the size of the spine increases period by period, until the spines of the second row are equal in size to those of the first (Fig. 4). In accelerated types, the second row is already well developed in the young individuals (Fig. 1).<sup>2</sup> In the modern *Tudicula spirillus*, a beginning of the second row of spines is indicated by a succession of faint elevations, each later one stronger than the preceding, but none reaching the dignity of true spines. When more than two spines occur, these follow the same rule, as may be seen in *Murex brandaris*, *M. tenuispina*, etc.

In all cases the spines appear on the spirals, representing periodic outgrowths of the emargination which originally formed the spiral. As already noted, the first spine occurs on the spiral occupying

<sup>1</sup> I have been unable to find that a specific or varietal name has been proposed for the forms with a double row of spines, and hence propose to use the above name for them. I am well aware that intermediate forms between those with single spinous keel and those with double spinous keel exist, but I do not consider that this militates against the specific standing of the two types.

<sup>2</sup> For a full illustration of the principal mutations of the Miocene *Tudiculas*, see Hörnes und Partsch,—Die fossilen Mollusken des Tertiär-Beckens von Wien. *Abh. d. k. k. geol. Reichsanstalt*, 1856, Bd. 3, Taf. 27.

the summit of the ambital angulation. The second row of spines generally forms on the spiral which separates the body of the whorl from the spindle. The larger spines are formed on the primary spirals, the smaller intermediate ones on the intercalated secondary and tertiary spirals. In a number of types these spines are independent (*Murex tenuispina*) while in others they become compounded. Thus in the majority of Murices, the spines of the later cycles do not become independent of those of the earlier cycles, since these earlier ones grow to such an extent that the independence of the smaller spines is impossible. Hence they become modifications upon the sides of the larger spines, and thus is produced the wonderful complexity of spine in such forms as *Murex palmarosae* and others. Here, too, as has already been shown (I, p. 934) the increase in complexity is progressive from period to period, the first formed spine on the ambitus (or shoulder angle) always leading the others. The degree of advance of the first over the second spine varies in amount in differently accelerated types; this variation is, however, phyletic and as such also progressive. In some types the second spine always has the complexity of the first spine in the preceding period, in others its complexity is comparable only with that of the primary spine in a still earlier period.

*Columellar plications and lirae.*—The development of these features also follows the law of progressive appearance and progressive intensification. Those types like *Fasciolaria*, *Rhopalithes*, *Latirus*, etc., which in the adult have several plications, are as a rule, free from these in the earliest stages. The only exception is in the case of accelerated types, which start conch-life already equipped with plications, as many of them start equipped with costae and spirals. In the more primitive types, however, the plications appear in succession, the first while the shell is still young, the others successively. In some cases the second plication has only reached half the size of the first in the adult shell. In types with numerous columellar plications, intercalated ones appear between the older ones. These begin chiefly in later stages of development, being absent or at least weak in the younger stages. This is well seen in the young of certain volutes, such as *Voluta musica* and *V. polyzonalis*, where the intercalated plications in

half grown shells are absent or much more weakly developed, than in the adult.

In the same way lirae appear later in the life of individuals, being absent from the earlier stages. They are furthermore often complicated by intercalations, which like the primary ones appear progressively.

#### SUMMARY OF APPEARANCE OF SHELL CHARACTERS.

Summarizing the results so far obtained, we note that all the characters of the shell appear in a definite order, and develop by a process of progressive intensification or growth. This law holds good in the most diverse types of gastropods as will be more fully apparent from the examples cited below as illustrations. Even where at first glance the order of development seems to be abnormal, it is seen on closer inspection that this apparent abnormality is due either to normal progressive acceleration—falling as such under the type of variation outlined in the next section, or to pathologic conditions, which cause a temporary, or sometimes permanent development of senile characters which in the normal course of the ontogeny would appear only towards the end of life.

Phyletic acceleration, or the condensation and elimination of stages normal to the ontogeny is one of the chief sources of anomalies in the ontogeny. When the elimination is at the beginning of the conch stage, the shell may be looked upon in the same light as a more primitive type in which the apical portion has been broken away. In both cases the available part begins some stages along the road of progress but in both cases the stages subsequently passed are the same, though one may go at express rate and the other at a slow pace. When however later stages are telescoped, as is the case in many accelerated forms (*Fulgur carica*, *F. eliceans*, *Fusus longicaudus*, several species of *Semifusus*, *Pugilina*, etc.) the recognition of the normal line of progress is not so easy. Nevertheless it becomes apparent that up to the point of telescoping, and from that point onward, the progress is a normal one. Merely an original detour has been cut off as a river in the course of its development cuts off a large meander, and so two points, originally far apart on the river's course are brought close together.

Many other characters of the shell, such as the outline of the spindle, and the formation of anterior and posterior canals, and the development of the color pattern, have not been touched upon, but they all proceed according to a uniform law of change. The Countess von Linden has endeavored to show that the transformation of the color pattern in marine gastropods follows Eimer's law, viz: longitudinal striping, spots, cross-stripings and uniform color.

#### ORTHOGENESIS IN PHYLETIC DEVELOPMENT OF GASTROPODA.

The protoconch, the last of the embryonic stages, is far less satisfactory for purposes of tracing phyletic relationship, than is the conch. Nevertheless, up to a certain point, it may, I believe, be confidently relied upon. That an early stage of the protoconch in the majority of gastropods is of the form of a simple naticoid coil with a well-marked umbilicus, has already been noted (Studies I). As stated in the first of these studies this form of the protoconch recalls the character of the earliest known coiled gastropod, i. e., *Stroparollina remota* of the lower Cambrian of the Atlantic coast province. Still earlier stages in the development of the protoconch show a capuloid form, which recalls the adult character of many of the early Cambrian shells described under various names. That all of these are not primitive but that some are phylogerontic, is shown by the fact that the earliest stages are enrolled while the later stages are non-coiling. Sardeson<sup>1</sup> has indeed insisted that my interpretation of such forms as *Platyceras primaevum* etc. as phylogerontic is erroneous, and he has attempted to show that the forms with slightly coiled apex are more advanced than those in which the apex is not coiled at all, and that the progress of development is from forms without any coiling through those with enrolled apex, to the close coiled types. That this is a complete inversion of the mode of coiling, must be apparent when we consider that the animal has no more power to enroll its apex, than it has to unroll it, and that, since the apical part is the first-built

<sup>1</sup> The Phylogenic Stage of the Cambrian Gastropoda. *Journal of Geology*, Vol. XI, p. 470-482.

portion of the shell, it represents the primitive condition and the straightened part represents the later condition. Thus the progress of ontogenetic development is from close-coiled to non-coiled, from which we are justified in deducing that the ancestor of the type with the enrolled apex was a closely coiled type, and that the loss of power to coil, shown in the adult, is a sign of old age of the branch which that individual represents. That the earliest types were non-coiling shells cannot be doubted: there is every reason for believing that they were patelloid in form, though modern *Patella* is a phylogerontic type, which in its adult characters has returned to the condition of its forefathers. This is clearly shown by the presence of the coiled protoconch which at once stamps this form as derived from a coiled ancestor. All deductions then based on the anatomy of the soft parts of *Patella*, which leave this fact out of consideration are necessarily faulty, since it is hardly conceivable that in all its characters this animal has either remained primitive, while the shell passed through a tremendous series of metamorphoses, or that the soft parts have likewise degenerated to such an extent that they have reached in all characters the condition of the primitive ancestor of the gastropods.

Another relationship that may be deduced from the structure of the protoconch of many highly ornamented types of shells, is that they were derived from an ancestor with simple ribs on rounded whorls. Thus the ancestors of *Fusus*, certain *Murices*, *Latirus*, *Tudicula* and other types were fusoid shells with simple ribs on smooth rounded whorls, if the structure of the protoconch of these types can be regarded as an indication of ancestral conditions. For in these types the last portion of the protoconch is ribbed with delicate vertical ribs but without spirals. While the community of descent of the genera cited from some early Mesozoic ancestor is probable, it does not follow that all ribbed protoconchs indicate a common ancestry. For when it is recalled that ribs appear independently in the most divergent types of shells, it need not surprise us to find that this primitive ribbed character has been pushed back into the protoconch stage in a number of different lines of descent.

There are, of course, not wanting those who deny that the characters of the protoconch can be regarded as indicative of phyletic

relationships. Indeed the common practice of classifying largely or wholly by adult characters has almost of necessity led to a minimizing of the value of protoconchial characters when they are recognized at all. When differences of protoconch features were found in types classed together as related from adult characters it was explained as the result of the influence of different physical conditions acting upon the embryo. This heterostylism as it has been called by Boettger,<sup>1</sup> is explained by him as probably having one of two causes — either it is developed through a process of selection, to give the animal a lighter shell, to enable the animal occupying it to change its location more easily and quickly — or it has the object to prevent the creature from sinking into the soft ooze of the deep sea bottom, in which for lack of food or for other reasons it would perish. This of course refers only to the young shell, for the size of the initial protoconch whorl can have little significance in the adult.

Heterostylism, or a difference in the character of the protoconch in individuals living under different conditions, has been shown to exist in *Murex tribulus* L., where Sturany found that the deep sea form differs from the littoral form in an embryonic end or protoconch with more strongly swollen apical whorl, and with an extra volution. *Fusus bifrons* and *F. paucicostatus* are also distinguished at an early age by the relatively more swollen protoconch of the latter, which is at home in deeper water (490–876 meters).<sup>2</sup>

These two cases were used by Boettger<sup>3</sup> to illustrate his heterostylism and to establish the non-validity of my contention that the character of the protoconch of *Fusus*, of *Clavilithes*, *Rhopalithes*, etc., are not only distinctive, but due to diversity of descent.<sup>4</sup>

<sup>1</sup> Boettger, O. Ueber Heterostylie bei Schneckenschalen und ihre Erklärung. *Nachrichtsblatt der deutschen Malakozoologischen Gesellschaft*; 1905, Heft 1.

<sup>2</sup> Sturany. Expeditionen S. M. Schiff Pola in das Rote Meer. *Zoologische Ergebnisse*, XXIII. Gastropoden des Roten Meeres. *Denkschr. Math. Nat. Cl. K. Akad. d. Wiss. Wien.*, 1903, Bd. 74.

<sup>3</sup> loc. cit.

<sup>4</sup> Grabau, A. W. Phylogeny of *Fusus* and its Allies. *Smithsonian Miscellaneous Collections*. Vol. XLIV, no. 1417, 1904.

A similar position with reference to my work is taken by Cossmann<sup>1</sup> whose criticisms are more fully considered beyond.

Referring again to the Red Sea shells cited by Sturany, and used by Boettger and by Giard<sup>2</sup> as illustrations of heterostylism in Gastropods due to diverse physical conditions, we note on reference to Sturany's illustrations that the difference between the protoconchs of *F. bifrons*, and *F. paucicosta* is one of degree and not of kind. Both protoconchs are of the same type, the true *Fusus* type; but that of *F. paucicosta* has a somewhat larger initial whorl. This species is a highly accelerated type, as compared with *F. bifrons*, and hence it is not surprising to find the protoconch partaking of this acceleration. Besides the initial larger whorl, the number of whorls appears to be less than in *F. bifrons* where  $1\frac{1}{2}$  smooth volutions, followed by a delicately ribbed portion constitute the protoconch. Reference to my figures and descriptions of protoconchs of *Fusus* will show many such variations, (see pl. xvii, figs. 1-4) all of which are mere modifications due to greater or less acceleration, but do not constitute an essentially different type of protoconch. Such a difference of type does however exist between the protoconchs of *Fusus* and *Falsifusus* and *Fulgurofusus*, and between *Clavilithes* and *Rhopalithes* as a critical study of these will no doubt convince anyone. Where in *Fusus* of the Red Sea, the deep sea form has a larger initial and fewer subsequent whorls in the protoconch than is found in the littoral species, the deep-sea form of *Murex tribulus* combines according to Sturany a large initial with more numerous subsequent whorls when compared with the littoral type. In the absence of figures and detailed description such as one has a right to expect in a work of the kind presented by Sturany, it is impossible to judge in what this difference really consists. Moreover, one is led to doubt the accuracy of Sturany's generalizations quoted with approval by Boettger, when the statement, "It appears from these tabulations that the deep-sea examples have a proportionally higher spire, due to the increase in the number of volutions," is compared with the table

<sup>1</sup> Revue Critique de Palaeozoologie Oct. 1904, p. 233, and Essais de Paleconchologie comparée, liv. 7, p. 225, 1906.

<sup>2</sup> Giard, Alfred. La Poecilogenie. Bulletin Scientifique de la France et de la Belgique, 1905, T. XXXIX, p. 160.



of measurements to which it refers. For here we find that the smallest number of whorls (6) is found in shells from the greatest depth (920 m.) while a littoral specimen has the largest number (9) except one which has ten volutions and was obtained from a depth of 740 meters. Judging by the actual number of whorls, there appears to be nearly a steady increase in the number from 920 meters to shallow water. Moreover, it does not appear from Sturany's table how he eliminates differences in age in the individual measured. Taking shells of the same number of volutions (8) and therefore presumably of the same age, we have for

920 meters in depth	— a length of 73 mm.					
920	"	"	"	"	"	$60\frac{1}{2}$ "
612	"	"	"	"	"	$41\frac{1}{2}$ "
212	"	"	"	"	"	57 "

Subtracting the length of the spindle we have in the same specimens the following height of spire of 8 volutions.

920 meters in depth	a length of spire of 35 mm.					
920	"	"	"	"	"	27 "
612	"	"	"	"	"	22 "
212	"	"	"	"	"	$23\frac{1}{2}$ "

the greatest variation being within the same depth. Since the number of volutions is here the same, this difference in height can only be ascribed to a difference of embracing in the earlier whorls. A detailed description of this difference would have been of extreme interest, and as a record of variation would have been far more valuable than the tabulation of lengths and numbers of volutions, which without further discussion are of very little significance and value.

So long as the difference of protoconchial characters lies in the somewhat larger size of the initial whorl, or the relative number of whorls, this difference may very well be regarded as due to the difference of environment. That the environment may influence the development by retarding or accelerating it, seems hardly questionable, and that as the result of such retardation or acceleration the circumferential growth of the original shell may increase proportionately more rapidly than the spiral growth, thus producing a larger initial whorl, is also comprehensible. As is shown by studies of the embryonic development of *Fulgur carica* and



*Sycotypus canaliculatus* the size of the initial whorl is determined by the size of the embryo long before it leaves the egg-case, and in fact the whole protoconch is formed and the animal has begun the building of the conch before it becomes free. The same thing is true of *Fasciolaria gigantea* and *Buccinum undatum* (see Studies II, p. 535). To what extent this intracapsular development is carried on in the species of *Fusus* and *Murex* cited, I have not been able to ascertain, but it is most probably the case that the protoconch stage is far advanced if not completed before the animal becomes free. The size of the initial whorl of the protoconch is then probably to be regarded as an expression of the size of the embryo, its rapidity of growth during the period of formation of the hyaline primitive shell, and the size it has reached before the deposition of the calcareous matter begins. The size of the yolk of the eggs, i. e., the initial food supply may, in turn, be considered as at least a partial factor influencing this rate of growth. The factors advocated by Boettger are thus secondary factors which may or may not determine survival. They may indeed have no significance whatever, for swollen initial whorls are found in *Fusus colus* which lives in from 10 to 20 fathoms and *F. mamoratus* which lives in even shallower water. Among the Volutes, too, which are comparatively shallow water forms, species like *V. musica* have a minute apical whorl while *V. rupestris* Gmelin, probably belonging to a separate line of development, has a large initial whorl. The initial whorl of the shallow water *Fulgurs*, is much larger than that of many deep water species of other genera.

Aside from the size of the initial whorl of the protoconch, its obliquity to the axis of coiling of the other whorls is a significant feature. This is found in shells with an emargination or canal, that is fusoid shells, and can be traced back to the beginning of this canal. If the initial emargination, however, forms some distance from the umbilicus toward the periphery of the whorl, the later whorls will coil on a different plane from the first, which is often partially embraced by or becomes sunken into the second whorl (Fig. 6). This early rotation of the first whorl, occurring as it does in the capsular period of development, must be due to characters inherent in the embryo — at any rate it is difficult to conceive how it can be a product of environmental influence on the

animal after emergence from the capsule. It is of course possible that this rotation of the axis of the initial whorl may be a result of the rapid increase in size of this whorl since it nearly always accompanies such rapid increase, in which case it is a secondary feature.

I have elsewhere<sup>1</sup> described in detail the protoconchs of *Rhopalithes* and *Clavilithes* from the Calcaire grossier of the Paris Basin, and shown their great distinctiveness, the species classed under *Rhopalithes* having a fusoid protoconch with few riblets, while typical *Clavilithes* has a papillose one of numerous whorls, with other distinctive characters. I also showed that each genus embraced a series of species which in their stages of development paralleled each other and ranged from the round whorled, ribbed and fusiform type through a number of progressive changes, to an extreme old age or phylogerontic condition. I further pointed out that in spite of this remarkably close parallelism, the generic characters remained constant, the protoconchs of the two series remained distinct and *Rhopalithes* was throughout marked by the presence of columellar plaits (not always visible in old shells unless the lip has been broken back) which never occurred in *Clavilithes*. Moreover, the other shell characters are such that any one familiar with these shells can separate the members of the two series almost at a glance and without reference to the protoconch or columellar plaits. In spite of this Cossmann<sup>2</sup> insists, and Boettger follows him,—that my distinction is based solely on the difference in protoconchs; and that I carry my faith in the essential constancy of the characters of the protoconch and their phyletic value so far, that I have allowed myself to separate into two genera what M. Cossmann, and others who are accustomed to collect and study these shells in their type-localities, consider to be varieties of one species only. This arraignment might be more serious were M. Cossmann and other high authorities on the shells of the Paris Basin accustomed to study their species serially, and to give due attention to the early conch stages. M. Cossmann has recently taken to a recognition of the diverse characters of protoconchs, and in his valuable "Essais" has illustrated many of them. Unfortunately these illustrations are extremely crude,—often merely a spiral line—

<sup>1</sup> Phylogeny of *Fusus*, etc.

<sup>2</sup> Cossmann. *loc. cit.*

and the wonderful detail shown by many protoconchs is wholly unrecognizable. As for the characters of the early whorls, and their progressive changes, M. Cossmann, like most conchologists, either deems them of minor importance or of none at all, and does not grant them the space they deserve in his descriptions. No wonder then that he should be horrified at my audacity in making a new genus, where he sees only a variety. I was well aware that the species separated by me under the genus *Clavellofusus* were classed by French conchologists as varieties of *Clavilithes parisiensis* (which M. Cossmann still insists upon uniting with the British *C. solanderi* under the name *C. deformis* coined by Brander for the young of that or a related species) for I had specimens labelled thus, presumably by M. Cossmann's own hand; yet I found, and continue to find whenever a new specimen of this series comes under my observation, that the section denominated by me *Clavellofusus* with the rank of a genus, is wholly distinct from, and has its own series of mutations parallel to those of *Clavilithes*. Moreover, if Deshayes is to be believed, this series belongs to the *Sables inférieurs*, while *Clavilithes* belongs to the middle Calcaire Grossier (though one species has been recorded from the *Sables moyens*) except the most specialized terminal member of the group *C. scalaris* which is confined to the *Sables moyens* or lower Upper Eocene. All my material has shown, and I believe that a careful and unbiased study of other material will show that the *Clavellofusus* series is distinct from *Clavilithes* of the Calcaire Grossier, that it runs through its own series of modifications, some accelerated or tachygenetic, other retarded or bradygenetic, and that these various mutations<sup>1</sup> are derived from a *Fusus*-like ancestor, possibly a *Fusus* itself, and not from *Clavilithes parisiensis*,—a species appearing much later and belonging to a distinct genetic series. The *Clavilithes* series is also derived from a fusoid ancestor but a very different one from that which gave rise to the *Clavellofusus* series. If M. Cossmann will admit that my *Clavellofusus* series is a distinct series, — no matter what its origin, — and I do not see how he can do otherwise unless he abjures all regard for phyletic principles — I care not whether he joins me in calling it a distinct

<sup>1</sup> I shall throughout use the term mutation in the earlier sense of Waagen.

genus with species each showing a distinct step in progressive development, or whether he makes the whole series a variety of something and calls my species subvarieties. But he cannot make the series a variety of *Clavilithes parisiensis*, any more than he can make the uncle the son of the nephew.

Professor Boettger will probably find it difficult to point out that the difference between the protoconch of *Clavilithes* and that of *Rhopalithes* is due to any difference in physical environment, as the fusoid members of the series, *C. rugosus* and *R. rugoides* occur side by side, the same being true of other members of the same series as well. Moreover, if he agrees with Cossmann, that *Rhopalithes* and *Clavilithes* are generically identical, he will have to show why the series with the *Fusus*-like protoconch has columellar plaits and why these are wanting in the series with a papillose protoconch.

Finally I may again call attention to the fact that I have described in detail the variation in the protoconchs of *Fusus* and that I have readily admitted the possibility of the existence of larger and smaller initial whorls, of an increase or decrease in the number of whorls in the protoconch, and of the variation in the number of riblets on the protoconch. In fact I have illustrated such variations but I am not ready to admit that there is ever a difference of type in the protoconch in what can otherwise be referred to the same genus. I have repeatedly shown, that the so-called species of *Fusus* from the American Eocene strata not only disagree utterly as regards the type of the protoconch with true *Fusus*, but that the young stages as well show much more acceleration than is found in the young of even modern *Fusus*. "*Fusus apicalis*" and "*Fusus houstonensis*" are an exception to this and it is not impossible, that in spite of the remarkable protoconch, these may be more nearly related to true *Fusi*, than is either *Falsifusus meyeri* or *Fulgurofusus quercollis*.

*Fusus aciculatus* and "*Fusus*" *serratus* occur side by side in the Calcaire Grossier of the Paris Basin, yet the first retains its normal *Fusus* protoconch while the second has a widely different type of protoconch, like that of many *Pleurotomas*. It will be difficult to explain on the hypothesis of any local cause of variation why *F. aciculatus* retains the early *Fusus* whorls, common to all true

*Fusus*, and always associated with the *Fusus* protoconch, while "*Fusus serratus*" with a distinct protoconch has whorls more specialized than those of any other true *Fusus*, even those of the present day. Why do the fusoid shells in which the normal post-embryonic developmental stages of *Fusus* occur, always have a *Fusus* protoconch, while those fusoid shells which do not show the true *Fusus* protoconch do not show the normal ontogenetic stages of true *Fusus*, if this is not an expression of inheritance, and of more fundamental significance than Cossmann, Boettger, or Giard are willing to admit? It is high time that we cease making generalizations and tracing relationship by a superficial study of shell characters. Such superficial study has deservedly brought the whole subject of conchology into disrepute, so that morphologists have come to look upon shell characters as the least reliable indices of genetic relationships, whereas they are really the most reliable and delicate of such indices, if subjected to a critical study.

#### ELIMINATION OF EARLY CONCH CHARACTERS BY ACCELERATION.

It not infrequently happens that the protoconch stops abruptly, and the conch begins as abruptly. In fact, it may be said that this is normal for such specialized types as the fusoid shells (Studies I, figs. 1 and 5). In normal primitive types the protoconch characters may be expected to merge by slow degrees into those of the conch. Such is the case even in types specialized along one direction or another. In highly specialized types, however, we often find an abrupt transition from the characters of the protoconch to those of the conch, these latter beginning suddenly with a number of special characters. Thus in *Fusus*, the protoconch ends abruptly with a strong varix, and the conch begins with round whorls, ribs and spirals. Here protoconch and conch have been telescoped, so that the transitional characters undoubtedly possessed by the ancestors of this genus were dropped out. Conditions of this kind exist in a number of types which may or may not be related to *Fusus*. Such relationship of protoconch and conch cannot of course be regarded as indicating consanguinity wherever it occurs, for it is clearly a stage in development, and therefore a condition, which may appear in the specialized terminal

members of any number of divergent genetic series. Conversely, however, the want of such accelerated conditions in members of the same genetic series may well be regarded as sufficient for generic distinction, though this is largely a matter of personal opinion regarding the elasticity of the generic boundaries. Even greater acceleration than this is shown by many genera. Thus certain species of *Semifusus* have dropped out the round-whorled ribbed stage, the conch beginning with the angular stage (Studies I, Fig. 5).

In many cases the early characters appear not to have been wholly dropped, but greatly condensed, so that the protoconch quickly merges into a highly specialized conch, the transitional stages being extremely short and often scarcely recognizable. Then, too, some of the early stages may drop out without the abrupt change seen in *Fusus*, etc. Thus characters which in the phylogeny of the group were developed only at a relatively late period after other characters had come into existence, may in the specialized members of this series appear immediately after the protoconch, the earlier characters being dropped out of the ontogeny. On the other hand, certain persistent characters may be pushed far back into the ontogeny, and appear even in the protoconch stage. This is seen in the riblets of the last whorls of many protoconchs (*Fusus*) and in the appearance of an angulation or carina in others (certain *Murices*, etc.).

Not only is acceleration by condensation and elimination active in the earliest conch stage, but it is often found at a later period, where some shell character, not strongly fixed in the organization, may be eliminated to make room for a later and more prominent one. This condition has already been briefly described for *Fulgur* and *Semifusus* (Studies I, p. 932) and more fully for *Fulgur* in a later paper (Studies II, p. 528). It may be briefly reviewed here.

In both genera, and in the case of *Pugilina* in what are commonly regarded as varieties of the same species, the tubercles are normally developed as a result of the concentration of the ribs upon the shoulder angle. This is characteristic of the earliest Miocene *Fulgurs* as well as the ancestral forms of *Semifusus* and *Pugilina*. With further development the tubercles grade into a keel and this into a smooth rounded and ribless whorl, differing from the

primitive rounded and ribless whorl in the presence of compound spirals. This is the condition of adult *Fulgur maximum* and certain forms of *F. rapum* of the Miocene. In more specialized types a series of spines appears at periodic intervals on the primary spiral which originally marked the angulation of the shell (Fig. 7). These spines at first small, increase in size progressively up to a certain point. They are simple triangular emarginations of the outer lip and often are abruptly abandoned, so that they remain open forward, though in other cases they are closed in front showing a more progressive abandonment of the spine. This diminution of the spine-forming emargination, is generally more rapid than its development. This condition of newly added spines following in the last whorl upon a smoothly rounded or slightly keeled, non-tuberculate whorl is characteristic of *Fulgur tritonis* (Fig. 7), *F. pilosum*, and others where a fraction of one whorl to several whorls without tubercles or spines separate the primitive tuberculate, from the last spinose whorls (Fig. 7). The same is true of varieties of *Semifusus colosseus* and *Pugilina pugilina* of the modern fauna (Fig. 8). Finally in the most specialized types, such as *Fulgur carica*, *eliceans*, etc., and the accelerated varieties of *Pugilina pugilina*, the spines have been crowded back to such an extent that the non-spinose stages have been dropped out. This telescoping has gone so far as to result in partial overlapping of the spinous and tuberculose stages, as a consequence of which the tubercles pass insensibly into the spines. All stages of this telescoping can readily be observed in large collections of the recent species of *Pugilina* cited.

The significance of this telescoping of characters is often not appreciated. That it cuts out ancestral stages and shortens the ontogeny by this elimination is evident, as is also the resulting vitiation of the phylogenetic record in the ontogeny. Moreover such an overlapping of characters destroys their individuality to a certain extent and makes the later appear to be a mere accentuation of the earlier whereas they have a distinct origin. Such telescoping has apparently occurred in a great number of phyletic series. In Eocene Columbarium, for example, the tubercles grade into the spines in the nepionic stage of the shell. In modern *Columbarium pagoda* (Fig. 6) the tubercles and ribs have been pushed



out of the ontogeny altogether so that the angulation of the ribless whorls and the appearance of true spines is almost simultaneous. Yet the Eocene species indicate that the genus passed through a normal series of round-whorled-ribbed, and angular-whorled-tuberculated stages before the spines appeared. As already noted, a second row of spines appears in several lines of radiation in this series. In the genus *Rhinocanthus*, typified by *Murex* (*Rhinocanthus*) *brandaris*, the principal spine likewise merges with the tubercles which here are formed without the loss of the ribs. The second spine has also been accelerated until it appears during or shortly after the tubercled stage. In the more specialized Murices, where the adult spines are compound, the early ones have been pushed far back and are inseparable from the tubercles or even from the ribs. It seems in fact that the spine-forming stage has become superposed upon the rib-forming stage for the ribs are characteristic of adult Murices of such relatively simple types as *M. brandaris* and of such highly complicated types as *M. palmarosae* as well.

In tracing the phylogeny of spinous gastropods it must be borne in mind that tubercles and spines have a different origin, and that where they appear to merge into each other this is due to acceleration. It is highly probable that the ancestral forms of such types will be found to have these two characters separated, the spines not being found in the earlier members of the phyletic series as has been demonstrated to be the case in *Fulgur*.

As has been shown above, the ontogeny of a great many widely distinct types of gastropods is marked by a progressive increase in the amount of embracing of the earlier by the later whorls. This results in a change of angle of the spire from relatively acute in young to often a rectangle or obtuse in the adult. In some types (*Conus*) the change may be to 180 degrees, rarely more. This same change is observable in the adults of the successive members of the corresponding phyletic series. Thus the Eocene species of *Fusus* are characterized by a slender spire throughout, while the modern forms usually show the slender spire only in the youthful stages, the adults becoming more broadly turreted. In *Tudicula*, the Miocene species show a more slender spire, especially in the young, than is shown in the modern species. A similar



condition is observable in *Turritella*, where the early species are generally more loosely coiled. Such looser coiling is also observable in the young of modern forms, in the adult of which the whorls embrace up to the angulation. Here however another factor enters in, the progressive flattening of the whorls so that the spire remains slender even though the whorls embrace to the ambitus. Similar conditions obtain in *Nerinea*, *Cerithium*, and others, the surface of the whorls even becoming concave in many of these.

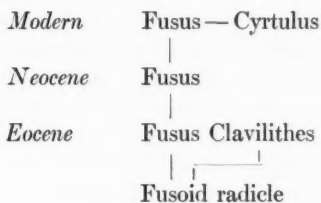
In its most pronounced form the progressive increase in the amount of embracing of the whorls is seen in phylogerontic types. Here this increase is accompanied by a loss of ornamentation and distinctive form. In its most striking form this excessive embracing is seen in *Melongena*, where the earlier whorls become to some extent enwrapped by the later ones, the form of these later whorls bearing no relation to that of the earlier ones, but being without the normal ornamentation of the earlier whorls (Studies I, fig. 9). Similar though more regular conditions are found in the clavilithoids for a discussion of which the reader is referred to my "Phylogeny of *Fusus*." Cossmann has recently reiterated his belief in the generic relationship of *Clavilithes* and *Cyrtulus* which latter type is a phylogerontic terminal of the modern *Fusus* series. This reassertion of his former position indicates that Cossmann has either not carefully read my arguments for the total distinctness in origin of these types — or if he did, that he does not consider them as valid. If this is the case I must give up all hope of convincing him, for I do not see that I can state the case more fully. If any one not biased by inherited ideas of relationship indicated by adult characters, will carefully compare the young of *Cyrtulus serotinus* Hinds with the nepionic and neanic stages of any species of *Fusus* of the *F. colus* series, he will be impressed with the similarity of these two types, a similarity which so far as the details shown are concerned, amounts to identity. I do not believe that any one can distinguish the young of *Cyrtulus serotinus* from that of any member of the *Fusus* series, unless he finds some characters not yet observed in these types. Certain it is, that the young of this species, is more nearly identical with that of any member of the *Fusus colus* series than with any other known gastropod. This similarity can only be the result of relationship, so that the unbiased

investigator will probably be forced to accept this evidence as indicative of community of descent. If we now take the most closely similar type of the Eocene clavilithoids, which I think all will agree is found in the forms I have classed as *Clavellofus* — but which Cossmann still considers varieties of *Clavilithes parisiensis* Mayer-Eymer (*Clavella deformis* of Cossmann) we find that its young leads us to some Eocene or earlier fusoid ancestor which may or may not have been the ancestor of the modern *Fusi*, including the *Fusus colus* series as well. Assuming, for the sake of making the argument as favorable as possible to M. Cossmann, that *Fusus* and *Clavilithes* had a common ancestor,— which, moreover, is probably the case — and allowing for the moment that my species of *Clavellofus* are varieties of *Clavilithes parisiensis* as Cossmann contends,— but which most certainly is not the case — if we allow this, where do we land? In the first place, if youthful characters show relationships at all,— and I doubt if in view of all the evidence accumulated along so many and diverse lines, even Cossmann will have the hardihood to deny this — it is evident that all the Eocene clavilithoids are derived from an Eocene or earlier fusoid ancestor, which we will allow was a true *Fusus* and the ancestor of the modern *Fusus* as well. Nevertheless, it remains true that *Cyrtulus serotinus* is a derivation of modern *Fusus* and not of Eocene *Fusus*, a point established beyond question by the character of its young.

If Cossmann were to contend that both the modern and the Eocene clavilithoids were derived directly from a common Eocene or earlier ancestor there would be some reason in his gathering all these divergent lines into a common generic boundary. The question would then be boiled down to that of the greater or less elasticity of the generic boundaries. But Cossmann holds that *Cyrtulus serotinus* is a descendant of *Clavilithes* (“quoiqu’elle [Cyrtulus] soit le descendant immédiat des Clavilithes”) although the young stages show that this is not the case, as every student of phylogeny of Mollusca as deduced from shell structure will readily admit on comparison. Unless, then, Cossmann can prove the direct derivation of *Cyrtulus serotinus* Hinds and *Clavilithes*

<sup>1</sup> loc. cit. 1904, p. 234.

*parisiensis* Mayer-Eymar (or better *Clavellofusus spiratus*) from a common Eocene or earlier ancestor, without the intermediation, in the *Cyrtulus* line, of modern *Fusus*, his proceeding would be almost as illogical as the classification of all ammonoids showing a corresponding degree of involution in the same genus. This will appear more clearly from a consideration of the following diagram.



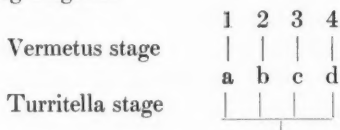
The only other way, in which *Clavilithes* and *Cyrtulus* can be made congeneric, is by also including *Fusus* in this genus, a stretching of generic limits, to which even M. Cossmann will most certainly object.

I have elsewhere<sup>1</sup> outlined in detail a number of genetic series among the *Clavilithoids* which, diverging probably from a common ancestor, produced similar end forms, just as divergent ammonite phyla often had end forms superficially alike. Whether the series which I have outlined to the degree of detail permitted by the available material, will be found to be complete, or will need modification in the future, remains to be seen. That the various series exist, is, I think, beyond cavil, and certainly cannot be set aside by a wholesale assertion of authority even on the part of the most veteran collector of these fossils.

It has already been outlined in the earlier part of this paper, that old age characters in gastropod shells are also shown by the loss of the power to coil, as is so commonly the case in cephalopods. That such characters have been taken as distinctive of new genera is not surprising, and indeed is desirable. Great caution however is necessary not to make this the sole distinguishing character, and class together terminal loose-coiling members of distinct genetic

<sup>1</sup> Phylogeny of *Fusus*. Smithsonian Miscellaneous Collections, vol. XLIV, no. 1417, 1904.

series. That this has been done in *Vermetus*, admits of little doubt. The Mesozoic and Tertiary species of this group represent phylogerontic terminals of various genetic lines of turritelloids, becoming extinct in these periods, just as modern species represent terminals of one or more lines of modern turritelloids. Even if the species of turritelloids are considered as congeneric throughout, the terminal vermetoids cannot be congeneric but merely represent a stage in development. Each terminal group would of necessity represent a distinct genus unless it were united in one genus with its corresponding ancestral turritelloid, as in the following diagram.



Thus if *a*, *b*, *c*, and *d* represent four diverging specific lines of *Turritella* and 1, 2, 3, and 4 the corresponding *Vermetus* form, these latter could not be classed as one genus, *Vermetus*, unless *a*, *b*, *c*, and *d* were also classed in the same genus. Each must be considered as a separate genus whether it has one or more species, but 1 and *a*, 2 and *b*, 3 and *c*, 4 and *d*, can each be classed as a distinct genus, with a turritelloid and a vermetoid species, or all species of vermetoids may be classed as *Turritella*.

This reasoning applies with equal force to the non-coiling forms commonly classed as *Platyceras*, this term having the value of a stage. A similar though very slight loosening of the last whorl is made the basis for the separation of the genus *Diastruma* from *Melania*, although pathologic individuals of the latter sometimes show an identical character (Fig. 19). That in the case of this so-called genus we really deal with a stage in development, and therefore with terminal members of different phyletic series, which ought to be united with their respective *Melania* ancestors instead of being classed together, becomes more apparent as the detailed study of these types progresses.

In extremely accelerated series it often happens that the mode of development appears to be reversed, the specialized character appearing first, and the less specialized later. Thus in certain

Melantias in *Cerithium*, *Turritella*, etc., ornamentations appear in the young which are lost in the adult. Without departing from an orthogenetic mode of development, the succession of characters developed seems to be inverted. In such cases it generally appears on study of the youngest stages that the simple characters of the adult are similar to the most youthful characters, before the most pronounced features appear. This feature will be described later in some detail in certain Melantias and is also seen in other specialized types. It is readily explained by referring it to degradational development, where characters acquired during the aggradational period are lost in the reverse order of their acquisition. Sometimes differential acceleration may account in part for this. Thus in some cases, the shell becomes carinate and only subsequently develops ribs. These may be a later acquisition having never before appeared in the phylogeny of this series. Whatever the cause of such development, the method is orthogenetic, the variation being in all cases progressive in one direction or another.

#### EXAMPLES ILLUSTRATING ORTHOGENESIS.

I have elsewhere described a considerable number of genetic series among the fusoid shells<sup>1</sup> and have also traced in some detail the development of the *Fulgur* and *Sycotopus* series (Studies II). It has there been clearly shown that the development is orthogenetic, both as regards phylogeny and ontogeny, and that the great governing principle in the production of diversity is acceleration or tachygenesis, and retardation or bradygenesis. To show more clearly the universality of this principle of orthogenetic variation among the Gastropoda, I will here append a somewhat detailed discussion of several phyletic lines among the Melantias, a group as distinct as possible from the Fusidae. Unfortunately in the specimens studied, the protoconchs were not available, so that all the deductions are based upon the characters of the conch, from its earliest to its latest stages.

Melania is well adapted to this sort of study on account not only of its variability, but also because it has so many characters upon

<sup>1</sup> loc. cit.

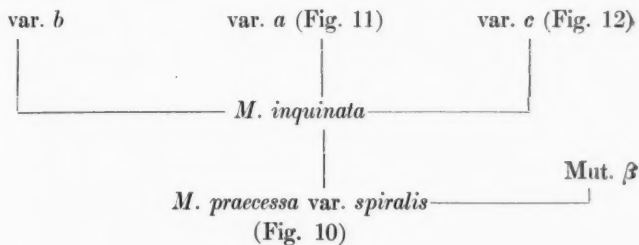
which we can seize for the purpose of determining the line of progress. The earliest types were undoubtedly marine giving rise on the one hand to the fresh water *Melantias* and on the other hand to a number of marine descendants. No exhaustive discussion is contemplated here, this and the tracing of the various genetic lines being reserved for a future work. Only some of the more salient features developed during the study of this group of shells will be mentioned here as illustration of the principles discussed.

The Eocene *Melanoides praecessa* and *M. inquinata* of the Paris basin may be taken as a starting point, though they already present characters of considerable complexity both showing a marked series of changes. In the former the earliest stages observed show rather flatly rounded whorls with distinct, narrow, rounded ribs which are concave forward (i. e., towards the aperture). These ribs are cancellated by revolving spirals which however are faint in the interspaces, but form pronounced nodules on the ribs. In some specimens the earliest ribs appear to be free from these tubercles, and the mode of appearance seems to indicate that the ribs precede the spirals. This is the character of the early stages of the type specimen figured and described by Deshayes (Des., An. sans. vert., II, p. 452, pl. 23, figs. 31-32) these stages being free from spirals. This character recalls the adult of *Pseudomelania* (*Chemnitzia*) *undulata* d'Orb., *Ch. carusensis* d'Orb., *Ch. corvaliana* and *Ch. periniana* d'Orb., from the Middle Lias and *Ch. rhodani* of the Upper Lias of France.<sup>1</sup> In later Jurassic strata of France occur many *Pseudomelantias*, which show no ribs in the adult. Some of these may however possess them in the young, as has actually been found in the case of *P. nereis* d'Orb. of the Bathonien. Such occurrences suggest that the smooth *Pseudomelantias* are derived from the ribbed ones and hence in so far as they have lost this character are phylogerontic.

In Eocene *Melanoides praecessa* var. *spiralis* var. nov. from Noyon (C. U. coll. 30041, fig. 10) the spirals become gradually strengthened, until they are well marked. The uppermost or posterior spiral becomes strongest; and gradually the space above it develops into a concave shoulder free from ribs. On this shoulder-

<sup>1</sup> D'Orbigny. Paleontologie Francaise.

angle develops a series of nodular spines, as the ribs gradually become obsolete, slightly fainter nodules being formed where the lower spirals and ribs cross. With the complete disappearance of the ribs, the lower spirals—of which there are four large and three smaller more closely crowded ones in the adult—become continuous and free from nodulations. No intercalated or secondary spirals occur, except in accelerated types, where the shoulder and nodules exist for only a few neanic whorls, after which they gradually disappear, only faint primary and secondary spirals remaining on the last whorl (Mut.  $\beta$  Fig. 9; C. U. coll. 30042). In the type specimen of *M. praecessa* figured by Deshayes, the ribs have not entirely disappeared in the adult. It represents a more primitive or more retarded individual than the Noyon variety described above, its adult features being comparable to the early neanic of var. *spiralis* Grabau. Three varieties of *M. inquinata* (Def.) are figured by Deshayes (Coq. foss. Em. Paris II pl. 12), of these var. *a* (Desh., figs. 3 and 14, our fig. 11) is the immediate successor of *M. praecessa* var. *spiralis*, but the tubercled character, which in that variety occurs only in the adult, is here found in the neanic and perhaps even in the nepionic whorls. Var. *b* (Desh., figs. 15, 16) is characterized by the suppression in the adult of all the spirals except the one on the angle, on which the tubercles become greatly strengthened, and the spiral just above the suture which is non-tuberculate. Both shoulder and body of the whorls become strongly concave in the adult. The third variety (*c*, figs. 7 and 8 of Deshayes) has all the tubercles suppressed, while the spirals become strong and the whorls below the shoulder rounded (Fig. 12). The phyletic relationships of these types may be expressed as follows, the length of line representing relative amount of divergence.



*M. praecessa* var. *spiralis**M. praecessa*

(Desh., An. sans Vert., II, pl. 23, figs. 31-32)

Jurassic ribbed *Pseudomelania*

(D'Orbigny, Pal. Francaise)

An interesting line of departure is shown in some specimens of *M. praecessa* var. *spiralis*. Here the second spiral from the posterior suture is the strong or primary one; *i. e.*, early in the ontogeny a new spiral appears above (posterior to) the primary one. This continues on the shoulder, and before the disappearance of the ribs becomes somewhat tuberculose. Intercalated spirals also appear on the adult whorl. This appears to have been the lineal ancestor of *Melania asperata* Lam. var.  $\beta$  Brot, of the Philippine Islands, a fresh water type (Figs. 14 and 15). The less accelerated individuals of this form show the early ribbed whorls, though these are marked by a large number of closely set extremely fine spirals not observed in the Tertiary species. In the individual represented by Fig. 15, a single row of spines makes its appearance after five or six volutions. These spines appear near the center of the exposed whorl, one on each rib, and begin shortly before the appearance of the ribs themselves (Fig. 17). At first the spines are very weak but gradually they increase in size, at the same time beginning earlier and ending abruptly upon the rib. Together the spines and their posterior prolongations produce the appearance of spirals. The single row of spines continues for almost four volutions the whorls gradually becoming divided into shoulder and body with the spines on the pronounced shoulder angle. A second row appears on the shoulder beginning as a faint elevation which is gradually strengthened.

In a more accelerated individual (Figs. 14 and 16), the second row of spines appears almost simultaneously with the first one though the lower row becomes somewhat more strongly accentuated.



Strong spirals appear on the body of the whorl without the formation of spines, one or sometimes two of these spirals appearing above the suture of the succeeding whorl. Intercalated spirals occur on the body of the last body-whorl.<sup>1</sup>

These *Melantias* therefore seem to be extremely accelerated, the spines appearing while the ribs are still in full force.

A type apparently retarded as far as the form is concerned is found in *M. dactylus* Lea from the Philippines (Martini Chemnitz *Melania* pl. 9, figs. 2 and 2a) in which two whorls of the adult are marked by narrow crescentic ribs cancellated by numerous spirals which appear in the earliest part of the ribbed whorls. The initial whorl is not known but the whorls immediately succeeding are smooth in appearance and embrace to the ambitus. Whether or not fine spirals occur on the earliest whorls is not ascertainable. The succeeding whorls embrace less, thus producing the slender spire. In the adult of many individuals the ribs become obsolete that being the usual line of development. Brot (Martini Chemnitz I 24, pl. 9, fig. 2a) however figures a specimen which successively acquires two rows of tubercles in the adult thus paralleling *M. asperata* var.  $\beta$  of the Philippines.

While these types show aggradational progression, modified by differential acceleration and retardation, other species referred to *Melania* show degradational progression, i. e., a progressive modification through suppression of characters. Certain Jurassic *Pseudomelantias* showing this have already been mentioned. A modern example is *Melania elevata* Say from Indiana. Here the late nepionic and neanic whorls are carinated, this carina gradually disappearing the shell becoming smooth and with scarcely impressed suture and with spirals only on the lower part of the whorl. The aspect is that of *Pseudomelania*, the character being derived through progressive reduction of features inherited from specialized ancestors.

The same thing is true of *M. deshaysiana* Lea, and *M. costulata* Lea from Tennessee. Here the order of development seems to be entirely inverted, the earliest whorls being carinated while the later ones show successive suppression of the carina, and the

<sup>1</sup> See Martini und Chemnitz, Syst. Conch. Cab. I 24 pl. 8, figs. 1, 1b and 1f.

strengthening of the ribs and spirals until in the spiral whorl the ribs and spirals gradually disappear. So far as shown by the specimens examined, which all lack the apical whorls, the ribs are absent from the early carinate whorls. It is possible that the carinate whorls are preceded by rounded ribbed whorls but of this we have at present no evidence. Should this eventually prove not to be the case, the explanation of these characters must be found in the early acceleration of the carina, which appeared on the smooth whorls before the ribs had appeared these latter not coming in until the time of disappearance of the carina. In *M. strigosa* Lea from the same locality, ribs seem to be wanting altogether, the early angular whorls passing by disappearance of the keel and spirals into a smooth adult form. Other species having smooth adult, and ribbed and spiralled youthful form are *M. rustica* Moussen (Martini Chemnitz pl. 17; 2 a, b), *M. palimpsestos* Reeve (Martini Chemnitz pl. 17; 3), and *M. hastula* Lea (Martini Chemnitz pl. 16; 3, a-d).

*Claviger subauritus* Brot represents the more primitive condition of that genus, in which the whorls are ribbed, the single row of tubercles being developed only on the last whorl (see Martini-Chemnitz I 24, pl. 36, fig. 11a).

The extremely spinose types of *Melania*s such as *Claviger byronensis* Gray (Martini Chemnitz pl. 36; 10a-c), and *C. auritus* Müller (Martini Chemnitz pl. 36; 7a-c), represent accentuations of one character at the expense of the others,—a one-sided acceleration. In the latter species the nepionic whorls show ribs and spirals the central of which become fused with two adjoining ones. This fused series quickly becomes accentuated in a pronounced tubercle, which increases in size and becomes variously modified while the remaining portion of the shell becomes smooth. At first the tubercles are near the middle of the whorl but gradually as they increase, the relative amount of embracing increases until the tubercles of the adult whorl lie just above the suture. In *C. byronensis* two groups of spirals become tuberculated, a third one occurring in some varieties.

A closely parallel series of variations is found in the modern *Potamides fuscatus* of Gambia. The nepionic and early neanic stages are identical with the adult of *P. granulatus* (Brug.) (*P.*

*corvenii* Fer.) of the same locality. This begins with a round-whorled ribbed stage passing into an angulated stage in which the spirals are prominent. The ribs progressively break up into tubercles, those on the median spiral being more prominent. In accelerated individuals (*P. radula* Linn.) the upper of the two median spirals has its tubercles slightly more accentuated than the lower, while a secondary spiral between them is also slightly tuberculated. The young of *P. fuscatus* Linn. shows the bicarinate whorls, the spirals forming the two carinae being tubercled. Somewhat later the upper series of tubercles becomes accentuated and a secondary spiral appears between the two. Up to this point, perhaps one fourth the length of the shell or less, all the stages except the earliest of *P. granulatus* are repeated, so that the young of *P. fuscatus* is in effect a diminutive *P. granulatus*. The further development of *P. fuscatus* is along the line of accentuation of the tubercles of the upper spiral, until they have become pronounced, sharp, and spine-like in the adult, all the other spirals, except the one just above the suture, disappearing in the most specialized examples. The series in this case is as complete as is that of the spinose Clavigers, and representative species, showing the same stage of development so far as the surface characters are concerned can be selected in both series.

The carinated Melanias represented by *Claviger matorii* Gray (Martini Chemnitz pl. 37; 3, 3a-f; 4, 4a-b) from Senegal show another interesting type of modification. The primitive species (*C. mutans* Gould, Martini Chemnitz pl. 37; 3b-e) are spiralled and ribbed, the upper spiral being the stronger. In somewhat more accelerated individuals the ribs are lost on the last whorl, but the spirals continue and become stronger, especially the upper one which begins to extend outward as a strong flange forming a deep notch or sinus in the lip. Somewhat more accelerated specimens show two or three final whorls in this condition, the flange of the last one becoming extremely pronounced, while one or in case of more loosely coiling individuals, two of the lower spirals also begin to be strengthened. Finally in extremely accelerated specimens, the ribbed and spiraled portion is restricted to the apical part, and it passes almost abruptly into a smooth shell on which the upper spiral makes a pronounced flange-like carina,

while the one just above the suture also becomes very pronounced. Sometimes this latter is prevented from taking part in the ornamentation of the shell by the close coiling of the whorls, the succeeding whorls crossing this spiral. (Martini Chemnitz, I 24, pl. 37, fig. 3-3a). Differentially accelerated specimens may have the flange pushed back into the ribbed portion; i. e. the flange appears before the ribs disappear. Then the flange is broken up into blunt vertically flattened spines which unite into a keel as soon as the ribs disappear entirely.

We have thus in the *Melantias*, a group of highly accelerated gastropods in which the spines,—a specialized feature, appearing late in the phylogeny of most gastropods—have become a dominant character, appearing before the ribs have disappeared. Many phylogerontic members of this group, forming terminals of genetic series, retain their ornamentation only in the young, the adults becoming smooth. In several lines extreme accentuation of certain characters at the expense of others has resulted in grotesque forms. All the characters, however, appear and disappear in a regular progressive manner both in ontogeny or individual development, and in phylogeny or the development of the genetic series. The *Melantias* therefore constitute an excellent group from which illustrations of ortho-ontogenesis and ortho-phylogenesis may be obtained.

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PLATE I.

- FIG. 1.—*Tudicula bispinosa* Grabau; young individual, showing beginnings of second row of spines. (Col. Univ. Coll. 30045.)
- FIG. 2.—*Tudicula rusticula* (Basterot); early stages enlarged  $\times 10$ , to show looser coiling and gradual appearance of spines and angulation. (C. U. Coll. 30046.)
- FIG. 3.—*Tudicula bispinosa* Grabau; a somewhat older individual than that shown by fig. 1. (C. U. Coll. 30047.)
- FIG. 4.—*Tudicula bispinosa* Grabau; showing two rows of spines fully developed (C. U. Coll. 30048.)
- FIG. 5.—*Tudicula rusticula* (Basterot); a characteristic adult form with a single row of spines.  
All the above are from the Miocene. Fahluns de Bordeaux.
- FIG. 6.—*Columbarium pagoda* (Less.) Recent protoconch and early conch stages enlarged  $\times 10$ , showing elimination of ribbed ancestral stages. (C. U. Coll. 39782.)
- FIG. 7.—*Fulgur tritonis* Conrad. Summit view of a characteristic specimen, showing the smooth neanic stage and the gradual development of the spines. (C. U. Coll. 30052.)



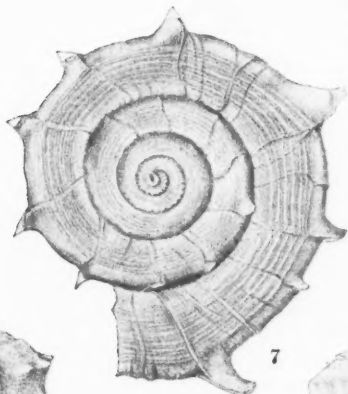
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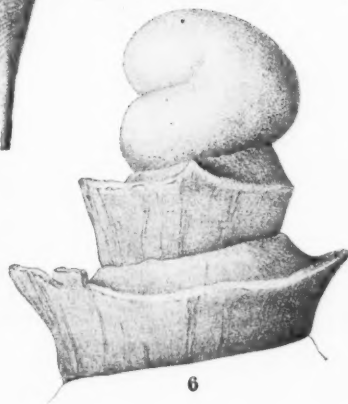
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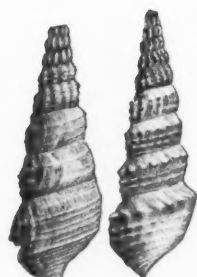
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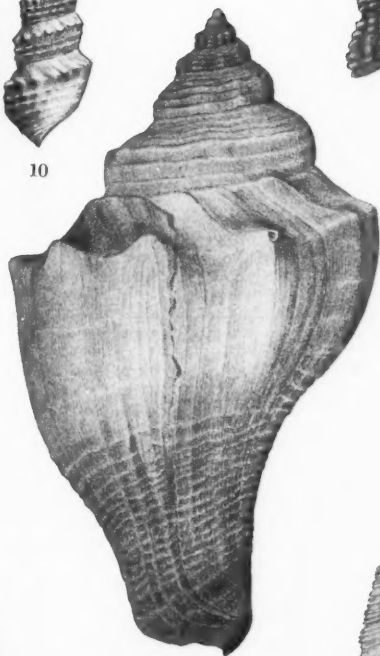
PLATE 2.

- FIG. 8.— *Pugilina pugilina* (Born); a primitive mutation retaining the smooth stage in the neanic. (C. U. Coll. 39818a.)
- FIG. 9.— *Melanoides praecessa* var. *spiralis* Grabau Mut.  $\beta$ ; showing disappearance of nodules in later stages. Lower Eocene, Noyon. (C. U. Coll. 30042.)
- FIG. 10.— *Melanoides praecessa* var. *spiralis* Grabau. Type. Lower Eocene, Noyon. (C. U. Coll. 30041.)
- FIG. 11.— *Melanoides inquinata* (Def.) var. *a* Desh.— Copy of Deshayes figure.
- FIG. 12.— *Melanoides inquinata* (Def.) var. *c* Desh.— Copy of Deshayes figure.
- FIG. 13. *Melania* sp. An unidentified species from the Tertiary of Abyssinia showing appearance of second and later spirals, partly by intercalation. Much enlarged. (C. U. Coll. 30054.)

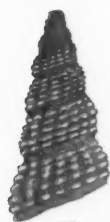


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PLATE 3.

- FIG. 14.—*Melania asperata* Lam. var.  $\beta$  Brot. Recent, Philippines. Accelerated mutation with two rows of spines appearing almost simultaneously. (See fig. 16.) (C. U. Coll. 41517.)
- FIG. 15.—*Melania asperata* Lam. var.  $\beta$  Brot. Recent, Philippines. A mutation with a single row of spines in the young. (See fig. 17.) (C. U. Coll. 41518.)
- FIG. 16.—*Melania asperata* Lam. var.  $\beta$  Brot. Enlargement of young stages of fig. 14.
- FIG. 17.—*Melania asperata* Lam. var.  $\beta$  Brot. Enlargement of early stages of fig. 17.
- FIG. 18.—*Melania* sp. An unidentified species from the Tertiary of Abyssinia showing appearance of third spiral by intercalation. Much enlarged. (C. U. Coll. 30053.)
- FIG. 19.—*Melanoides praecessa* var. *spiralis* Grabau. A senile individual showing loosening of last portion of whorl, a feature regarded as characteristic of *Diastoma*. Enlarged  $\times 2$ . Eocene, Bordeaux. (C. U. Coll. 30043.)



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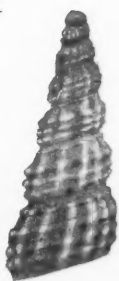
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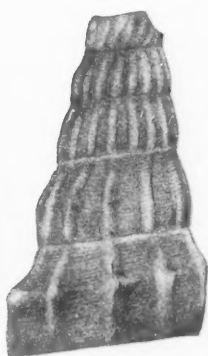
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## MUTATIONS AND THE GEOGRAPHIC DISTRIBUTION OF NEARLY RELATED SPECIES IN PLANTS AND ANIMALS

J. A. ALLEN.

In the *American Naturalist* for April, 1907 (vol. XLI, pp. 207-240) Robert Greenleaf Leavitt has discussed with great clearness and discrimination "The Geographic Distribution of Closely Related Species," with more special reference to plants than to animals, and also with reference to the bearing of the facts of distribution upon the mutation theory of de Vries. After presenting an impressive array of facts regarding the distribution of nearly related species, or "forms," in several widely different groups of plants, in part based on his own studies of the Orchidaceae, he gives his personal impression of the matter, stating in his concluding remarks that it seems to him "that the study of specific distribution in the vegetable kingdom is not likely to be unfavorable to Mutation, regarded as a method, but perhaps not the sole method, of evolution." He concludes: "The indications are that the adherents of Mutation will be able to bring forward enough cases of social distribution to render phyto-geographic weapons useless in the attack upon this Theory."

Taking the facts of animal geography, as stated by a large number of zoologists, "we may say," says Leavitt, "that as a whole they militate against the operation of Mutation in a wide sense in the animal kingdom. This conclusion," he adds, "is not prompted by the attitude of certain of the zoologists mentioned . . . but is drawn from the geographic evidence."

In his final generalizations he offers this very judicial statement: "First, we note that zoologists and botanists are rather distinctly opposed to each other in their views of the actual state of specific distribution. The suggestion is offered that zoologists may best discover the condition and interpret its meaning among animals, and botanists among plants. In no case is it safe to reason deduc-

tively from one kingdom to the other. In the factors affecting their evolution plants and animals differ vastly."

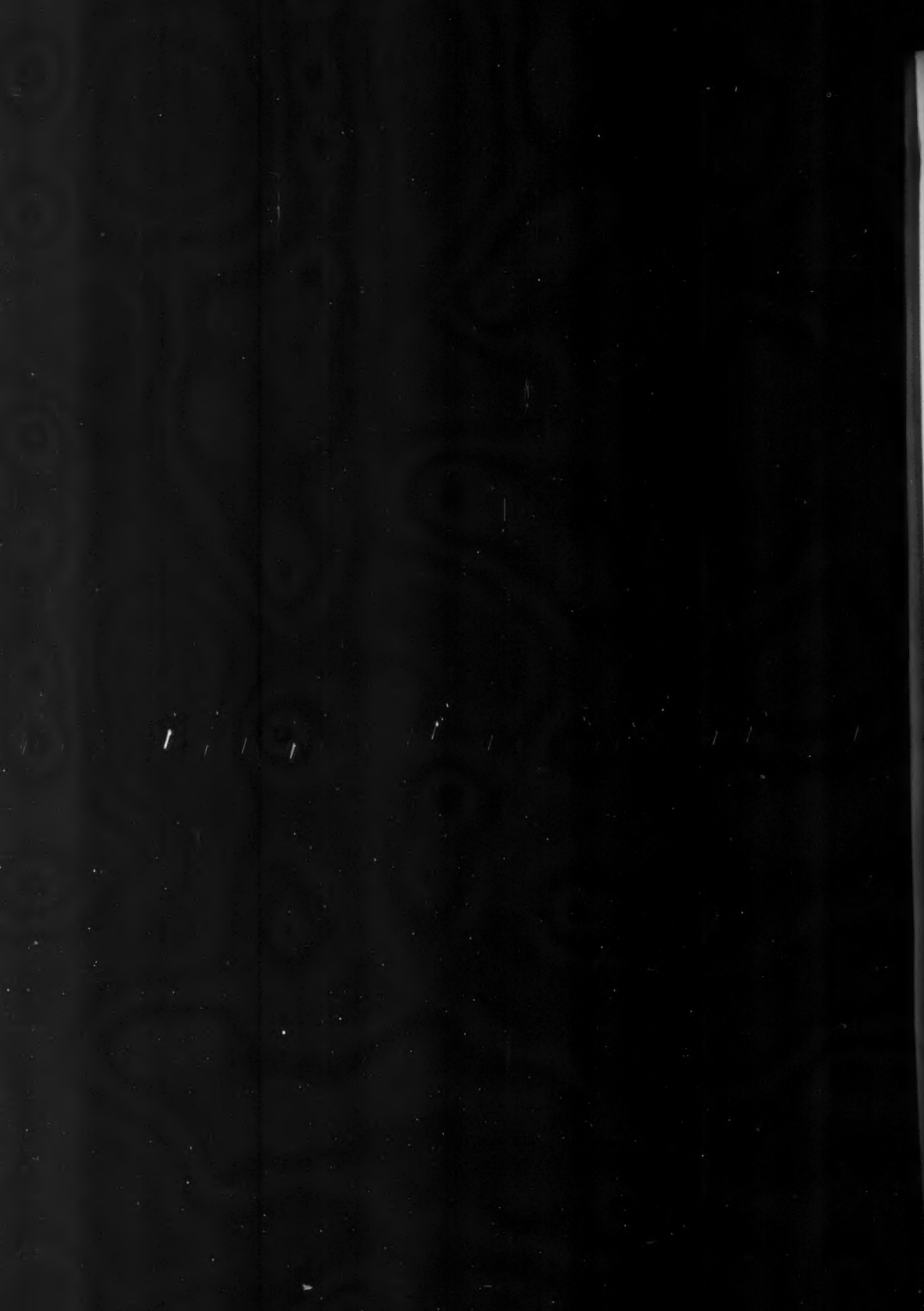
Here is a concession from the side of the botanists that should do much toward harmonizing the conflicting views of botanists and zoologists respecting the influence of 'mutation' in the evolution of forms among animals and plants. In the first place the conditions of reproduction, structure, growth, etc., in the two kingdoms are so radically different that the methods of evolution may also well be different; indeed, it would be surprising to find them not so.

Mr. Leavitt's paper is primarily a contention that President Jordan's law respecting the distribution of nearly related species does not hold in the vegetable kingdom. It is assumed that Jordan's law was intended to apply equally to both animals and plants, which interpretation seems to be supported by the context of the paper. The law is as follows: "Given any species in any region, the nearest related species is not likely to be found in the same region nor in a remote region, but in a neighboring district separated from the first by a barrier of some sort." If we substitute in this expression the word 'kind' or 'form' in place of 'species,' and restrict its application to animals, it will probably meet with general approval on the part of zoologists.

In testing Jordan's law by an examination of the facts of distribution presented by the Orchidaceae, Leavitt says he "looked for pairs of kinds," and adds: "I say kinds instead of species intentionally. The main problem should not be confused by the difficulty of agreeing upon a definition of species. What the evolutionist has to account for is not the definitions of systematists, but the multiplicity of hereditary types; he has to explain the antithesis between the uniformity which heredity seems at first to promise, and the diversity which actually prevails among organic things." It is evident, however, that in the expression "pairs of kinds," the term kinds is given unequal breadth of meaning in different instances, and is not here the equivalent of "nearly related forms," or "subspecies," as these terms are employed by zoologists. As regards the higher vertebrates, the evidence is indisputable that two closely related forms do not occupy the same area. By this expression the subspecies of zoologists are meant,—in other

words, intergrading forms of a common stock. It is therefore perfectly evident that botanists and zoologists are often speaking of entirely different concepts when discussing the occurrence or non-occurrence of species in the same area. It is also evident that minor forms among plants bear no relation to the minor forms among animals, either in mode of origin or in manner of distribution. In *Crataegus*, *Rubus*, *Amelanchier*, *Viola*, *Aster*, and countless other generic groups of plants, there often occur many slightly differentiated forms growing side by side over large districts. Among animals, at least among vertebrates, no such conditions appear to obtain; the slightly differentiated forms occupy different areas, and where the borders of their breeding ranges approach they gradually merge the one into the other with the gradual change in the environment. In the case of the plants mentioned, these slight differentiations maintain themselves despite similarity of environment; in the case of the animals, they are obviously the product of environment. The origin of such plant forms may never be discovered, but to many minds their development by mutation may seem not improbable. So long as we do not find similar conditions among the higher animals, it is hard to see how mutation has been active in the origination of new forms, whether species in the usually accepted sense, or the minor variants usually recognized as incipient species or subspecies. With these facts and conditions in view Dr. Leavitt's above-quoted suggestion that "zoologists may best discover the condition and interpret its meaning among animals, and botanists among plants," is eminently worthy of serious consideration. It is "obviously unsafe," as he well says, to reason deductively from one kingdom to the other.

A recent re-reading of the various recent papers by botanists and zoologists on the subjects of "mutation" and the "distribution of closely related forms" in animals and plants has given me the impression that much of the opposition of views on these questions is due in part to too sweeping assertions by both botanists and zoologists, in part to a misunderstanding by one side of what the other side really means, and largely to deductive reasoning from wholly dissimilar conditions.





## NOTES AND LITERATURE

### SCIENTIFIC EXHIBITS AT THE SEVENTH INTERNATIONAL ZOOLOGICAL CONGRESS

From the 19th to the 24th of August, American scientists were privileged to entertain the delegates and members of the International Zoological Congress at the Harvard Medical School, in Boston. The congress met in ten sections, and its program announced the titles of three hundred papers. The scientific exhibits, which were of unusual interest, are briefly described in the following paragraphs.

**Paleontology.**—Professor A. W. Grabau of Columbia University exhibited five series of spirifers of the *S. mucronatus* type, to show the gradual evolution of five species along parallel lines. The most primitive and oldest forms, from the middle Devonian (lower Hamilton), are long-winged and flat. They gave rise to the five independent series under discussion, in each of which the shells range from long-winged flat forms to those which are short-winged and round. Progress is always toward the rounded form, as shown both by the dimensions of the average shell in a given group, and by the extreme variations. Thus the most elongated shells in any group are not as long as the extreme examples from a lower horizon, but the most rounded forms surpass any which occur in the deeper strata. As shown by the lines of growth on the shells, the young stages in a given series are more elongated than the mature forms, thus resembling the adults of the preceding type. Thus the series demonstrates a gradual orthogenetic development of species, which, since similar changes occur in different localities, is presumably independent of environment.

Professor W. Patten of Dartmouth College exhibited a superb collection of *Bothriolepis* from the Devonian of New Brunswick. *Bothriolepis* is a fish-like invertebrate about ten inches long, consisting of an oblong cephalo-thorax covered with sculptured dermal plates, and a slender body free from scales but bearing dorsal and caudal fins. A strong, spine-like swimming appendage projects from either side of the thorax. Professor Patten has described and figured *Bothriolepis* in the *Biol. Bull.*, 1904, vol. 7, p. 105-124, and the related *Tremataspis* in the *Amer. Nat.*, 1903, vol. 37, p. 223-242.

*Bothriolepis* presumably lived in fresh or brackish water, and moved in large schools. One of the slabs showed some ten individuals headed in the same direction. Ferns and plant stems turned in the opposite direction showed that they were moving against the current. Another slab contained four specimens moving in the same direction but lying at different levels, indicating that two at least were buried in the sand when killed. The internal structure of *Bothriolepis*, including its stomach and the arrangement of its gills, was shown in serial sections of the fossils. In studying the ancestry of vertebrates Professor Patten desired further knowledge of *Bothriolepis* than could be supplied from any existing collection, and therefore he collected for himself the group of fossils exhibited. His theory of vertebrate development from arthropod prototypes was illustrated by some fifty clay models. They were designed "to show how the earlier vertebrate stages are but a further specialization of the later stages of an arachnid. The models show the origin of the blastopore, the unfolding of the cranial sense organs, the relation of the cranial neuromeres to the cephalothorax, the origin of concrescence, the derivation of the operculum and branchial chambers, the lateral fold, visceral arches, and the union of the anterior visceral arches on the haemal side to form the premaxillae, maxillae, and mandibles." One series of models illustrated the relation between echinoderm larvae and arthropod half-embryos; another series showed similarities in the mode of attachment of the larvae of cirripeds, echinoderms, and vertebrates; and a third presented a suggestive comparison of the brains of the scorpion, horse shoe crab, and primitive vertebrate.

Dr. C. R. Eastman of Harvard University showed specimens of the head shields of lung fishes, so that the well known Scottish Devonian form could be compared with the less known Canadian *Scaumenacia*, and also with existing lung fishes.

Mr. C. H. S. Sternberg of Lawrence, Kansas, who has collected fossils for forty years, exhibited some tortoises from the Cretaceous "Red Chalk" of Kansas, together with a specimen of *Hesperornis regalis*. The latter does not include the skull, but the cervical vertebrae were found, and show that the bird had a longer neck than some have supposed. The skeleton of the feet and legs is complete and the pelvis is well preserved. The divergent position of the legs is similar to that seen in divers and loons. Mr. Sternberg is about to publish a popular account of his experiences as a collector, entitled "The Life of a Fossil Hunter," for which Professor H. F. Osborn has written an introduction.

**Zoology.**—Dr. C. F. Rousselet of London exhibited fifteen slides of rotifers. They were remarkably fine, since by a special method the animals had been preserved in an extended condition. They were killed in a  $\frac{1}{10}\%$  aqueous solution of osmic acid, and sealed in 7% formalin on hollow ground slides. During the congress Dr. Rousselet identified fifteen species of rotifers which he obtained in one "dip" from the pond in the Public Garden.

Professor J. A. Thomson of the University of Aberdeen showed new and rare forms of corals chiefly from the Indian ocean. They included a specimen of the remarkable new genus *Studeria* from the littoral region of the Andaman Islands.

Miss E. R. Gregory, professor of biology at Wells College, New York, demonstrated the structure of the sand dollar, *Echinarachinus*.

Drs. F. B. Sumner and J. W. Underwood have studied "the seemingly protective coloration of the gastropod *Litorina palliata*" at Woods Hole, and they exhibited water color drawings, made by K. Hayashi, of the shells and the sea weed upon which they live. The shells vary from dark brown or black to bright yellow, and they may be either uniform in color or striped. The sea weed also ranges from dark brown to yellow. The snails, however, do not select appropriate backgrounds, either experimentally or in nature. Over variously painted sectors of a glass dish their distribution is purely by chance, and in nature yellow shells are found on brown weed and vice versa. As far as experiments have shown, the fish called tautog is as likely to take shells from the surroundings which they match as from others. It is possible, as has been suggested for other forms, that the pigment of the shells is the assimilated pigment of the weeds and matches them accordingly. Dr. Sumner's work is still in progress.

Professor W. C. Curtis of the University of Missouri demonstrated specimens showing the formation of segments in the tape worm *Crossobothrium laciniatum*, which occurs in the sand shark. Usually in tape worms new segments are formed near the anterior end, so that the most anterior segment is the youngest and the most posterior is the oldest. This is true of *C. laciniatum* until about 35 segments have been produced. Then, in the unsegmented region immediately behind the head, a new series appears, of which the most anterior is the oldest and the most posterior is the youngest; thus the body is segmenting from both ends toward a middle portion. When 50 anterior segments and more than 400 posterior segments have been formed the unsegmented middle portion is obliterated. After many of the posterior segments have become mature and been detached,

the neck region elongates, and a new set of segments may be produced, consisting like the first set of an anterior and a posterior group of segments. An account of this investigation was published in the *Biological Bulletin*, 1906, vol. 11, p. 202-229.

Professor R. Heymons, curator of the zoological museum in Berlin, showed several larvae of a beetle of the genus *Tenebrio* which had macroscopic rudiments of wings,—a pair on the mesothorax and metathorax respectively. Since the larvae were not reared, the time of the first appearance of the rudiments was not determined. It was observed that small rudiments were shed in molting but that the larger ones remained and finally expanded into the wings of the adult. External wing rudiments on larvae of insects undergoing complete metamorphosis are very rare. They have been observed in a few other coleopterous larvae (*Anthrenus varius*) and are probably "instances of premature development."

Dr. F. E. Lutz of Cold Spring Harbor exhibited specimens of the fly *Drosophila*, showing variations in the venation of its wings. The arrangement of the veins in wings of flies is usually quite constant. A disturbance of the normal arrangement sometimes occurs in *Drosophila* in nature, and by breeding selected individuals the disturbing factor has been increased. It is inherited somewhat, but not absolutely, in Mendelian fashion, and appears to be independent of environment.

Dr. S. Metalnikoff of the Imperial Academy of Science, St. Petersburg, showed sections illustrating the immunity of the moth *Galleria melonella* to the bacilli of tuberculosis. An hour and a half after injection, the bacilli were found within the blood corpuscles, and the remains of bacilli were detected in the corpuscles five days after injection. The bacilli become transformed into brown pigment. In the tissues the bacilli were found encapsulated three days after injection; a week later they were nearly all transformed into pigment. Finally the brown pigment is absorbed by the pericardial cells.

Mr. J. H. Emerton of Boston exhibited a large and well mounted collection of spiders, preserved in small vials of alcohol. The vials containing the forms and sexes of one species were attached to a large card, upon which were notes, drawings, and usually a photograph of the web. Many of the notes and drawings have been published in "The Common Spiders of the United States" (Ginn & Co., 1902),—an attractive introduction to the study of these arachnids.

Dr. A. Petrunkevitch of Short Hills, New Jersey, demonstrated the image-forming capacity of the lenses of spiders' eyes. The

integument of a *Lycosa nidicola* was removed, carrying with it the eight eyes. From the under surface of the preparation the retinae and vitreous bodies were brushed away, leaving only the lenses in position. The integument and lenses were mounted upon the stage of a microscope, beneath which a postal card was placed upon the table. With a  $\frac{3}{4}$  inch objective, eight magnified inverted images of the McKinley portrait could be seen so distinctly that the surrounding inscription was legible. The vision of the spider depends, however, upon its retina and central nervous system. A preparation of the retina was exhibited to show the coarseness of the rods. Since an image which is so small that it falls upon only one rod would be perceived as a point, Dr. Petrunkevitch has calculated the distance at which a spider can possibly recognize another spider, and in other ways has studied the nature of spiders' vision.

Professor E. L. Mark of Harvard University exhibited live *Amphioxus* from Bermuda. They are nearly transparent creatures about two inches in length, which remain buried in the coarse shell sand with their anterior ends projecting slightly from the surface. If disturbed they dart through the water with the greatest rapidity and by a wriggling motion promptly disappear in the sand. It was noted that about the British Isles and in the Mediterranean, *Amphioxus* inhabits sand of a similarly coarse texture.

Professor H. F. Nachtrieb of the University of Minnesota demonstrated several features of *Polyodon*, the spoon-bill sturgeon. The "bill," or flat anterior prolongation of the head, contains a central cartilaginous axis and two layers of a network of bony spicules, the spicules being easily separated in potash. Nerves extend along the axis and radiate peripherally to the skin, and especially to the primitive pores. These are clusters of pits surrounded by the patches of pigment which give the bill a mottled appearance. Dissections of the bill and sections of the pores and pigment cells were shown. The variations in the lateral line were indicated in dissections and photographs, and it was noted that the lateral line extended out on the dorsal lobe of the tail nearly to its tip. It was formerly thought to end nearer the base of the tail, as in other fishes. Professor Nachtrieb is studying further the innervation of the lateral line.

Professor W. A. Locy of Northwestern University exhibited dissections of *Scyllium*, *Trygon*, *Raja*, and *Pristiurus* to show the nervus terminalis. This is a ganglionated nerve situated near the olfactory nerve and passing to the olfactory region. It was discovered by Professor Locy, and has been described in twenty-four genera of

selachians and in lung fishes. It is considered to be a primitive nerve belonging with the morphological tip of the body, which has been replaced in the higher vertebrates by the development of adjacent nerves.

Mr. C. W. Beebe of New York exhibited bird skins to show the changes in color produced by exposing a bird to excessive humidity during successive molts. The spots of a wood thrush become larger and darker. The breast of the white-throated sparrow becomes slate-colored and the entire bird is abnormally dark. The feathers of the Inca dove become black-edged, and the bird passes through a stage resembling the normal scaly dove to a dark condition which is unknown in nature. It has been generally recognized that birds are darkest in humid regions and palest in arid regions, thus forming numerous subspecies.

Dr. J. A. Allen of New York showed a series of skulls of Sinaloa deer collected within a radius of twenty-five miles. They presented extraordinary variation in the premaxillary, maxillary and nasal bones, which was not correlated with age or sex. A series of skulls of peccaries showed variations in the orbital region believed to be due to parasitic insect larvae. The skulls had not been examined when fresh so that the presence of parasites was not determined. The bilateral symmetry of the modifications of the orbit led some to question their parasitic origin.

Professor B. G. Wilder of Cornell University exhibited photographs of human cerebral convolutions.

**Embryology.**—Dr. J. Warren of the Harvard Medical School showed a series of eighteen wax reconstructions of the pineal region in *Necturus*, *Lacerta*, and *Chrysemys*. In all of these forms the paraphysis develops as a median outpocketing from the roof of the brain, anterior to the pineal body. In the adult *Necturus* the paraphysis is a macroscopic gland-like organ, consisting of anastomosing tubules between which are sinusoidal vessels derived from the sagittal sinus. Dr. Warren's models of the developing and adult paraphysis in *Necturus* have been described in the *American Journal of Anatomy*, 1905, vol. 5, pp. 1–28. His study of the paraphysis in reptilian embryos is not yet complete.

Professor R. J. Terry of Washington University, St. Louis, exhibited a reconstruction of the pineal region in the toad fish, *Opsanus* (*Batrachus*) *tau*. The general topography of this region corresponds closely with that of selachians (*Squalus acanthias*) but the paraphysis, which is well developed in the latter, is indicated in *Batrachus* only by a slight irregularity in the roof of the brain.

Professor Terry showed also a wax reconstruction of the skull of a cat embryo of 23.1 mm. This model, which is beautifully constructed, is of special interest in comparison with other similar models of chondrocrania,—Professor Gaupp's model from *Lacerta*, Dr. Tonkoff's model from the chick, and Professor Hertwig's model from a human embryo of 8 cms.

Professor J. W. van Wijhe of the University of Groningen, Holland, has perfected a method of making embryos transparent after a deep selective staining of their cartilages with methylene blue. The resulting preparations show the cartilaginous skeleton as clearly as the familiar transparent potash-glycerine preparations reveal the bony skeleton. This new and valuable method was used in demonstrating the development of the chondrocranium of birds, twenty specimens of which were shown under two inch objectives.

Professor W. A. Loey showed the aortic arches in chick embryos injected with ink while the heart still pulsated (a method devised, we believe, by Professor Mall). The embryos were then dissected so that the fourth and pulmonary arches were clearly shown, together with the small subdivision of the latter, which is described as the fifth arch. This fifth arch was the object of the demonstration. Its small size as compared with the other arches was evident, yet in the chick it is presumably a larger vessel than in mammals.

Professor S. H. Gage of Cornell University has obtained the glycogen reaction to iodine in sections of the medullary plate of *Amblystoma*, and also in nerve cells and in the deep layer of the retina in young lampreys. These tissues, which were exhibited, are additional examples of the wide occurrence of glycogen, especially in embryonic tissues, which Professor Gage has already demonstrated.

Professor Wilder showed the "smallest known embryo of the manatee,"—a specimen approximately an inch and a half long.

Dr. J. L. Bremer of the Harvard Medical School exhibited reconstructions of the brain, pharynx, and liver of a human embryo of 4.0 mm. The brain is of particular interest since the neuropore is still widely open. In other human embryos of similar dimensions it is nearly or quite closed. This indicates either considerable variability in the time of closure, or that this embryo is abnormal. It presents, however, no other evidence of abnormality so far as is known.

Dr. F. W. Thyng of the Harvard Medical School exhibited wax reconstructions of the pharynx, stomach, pancreas, and cervical region of a human embryo of 13.6 mm. The jugular lymph sacs were modelled, probably for the first time in a human embryo. They



correspond essentially with the jugular sacs of the pig, rabbit, and cat. Each sac apparently communicates with the veins by a remarkably small opening which was not shown in the model. Dr. Thyng exhibited also models of the dorsal and the ventral pancreas in the rabbit, cat, and pig, one model of the latter including a well developed accessory pancreas.

Professor T. G. Lee of the University of Minnesota was the first to study the implantation and early development of the Sciuromorpha, the suborder of rodents which includes squirrels, chipmunks, prairie dogs, and gophers. Representatives of the other three suborders of rodents have been studied by other investigators. The Sciuromorpha have a characteristic early development. Before the placenta has formed, the vesicle acquires a temporary uterine attachment by means of a knob-like proliferation of cells on its ventral surface. *Geomys bursarius*, the pocket gopher, which belongs to a distinct family, perforates the epithelium of the uterus and develops in the uterine connective tissue. The aperture in the epithelium does not become closed as in the guinea pig, nor plugged as in man, so that *Geomys* is said to differ "in certain respects from any other mammal yet described." It may be noted that in the syncytial covering of the vesicles of all the Sciuromorpha the cells divide only by amitosis. Professor Lee exhibited a few of the interesting sections from his extensive series.

Dr. M. Herzog of Chicago has studied a very young human embryo in process of implantation. The sections exhibited were similar to those figured by Dr. Peters in 1899 as "the earliest known stage of human placentation." Because of their good condition and the rarity of such early stages, they are of great interest. The material is unquestionably normal, since it was obtained from the autopsy upon an individual who was accidentally and almost instantly killed upon the street; for such material it is unusually well preserved. Dr. Herzog has completed the study of the chorion and will soon finish that of the embryonic area and its appendages. The results will probably be published in the American Journal of Anatomy.

**Cytology.**—Dr. F. E. Botezat of the University of Czernowitz, Austria, was the first to demonstrate the presence of taste buds in birds. They were previously known in all other classes of vertebrates. His preparations of taste buds in the hard and the soft palate of *Passer domesticus* were shown by Dr. Gudernatsch. Preparations of Vater-Pacinian and Merkel's corpuscles from the tongue of the sparrow were also shown, demonstrating the neurofibrillar net and the end plates.

Dr. J. F. Gudernatsch of the University of Czernowitz exhibited sections of taste buds in the dugong. In the back part of the tongue there are certain large glands, the ducts of which expand into cup-shaped cavities near their outlets. In one of these cups there may be two or three elevations pitted with taste buds. The taste buds also occur occasionally along the deeper portion of the ducts. There are no vallate papillae, and no taste buds are found in connection with the small form of lingual glands. In the three orders of aquatic mammals taste buds are either absent, as in Cetacea, or they are not well developed, as in the Pinnipedia and Sirenia.

Professor S. Apáthy of the University at Klausenburg, Hungary, showed three series of cytological preparations, and demonstrated some ingenious devices used in making them. The perfection of his technique, as well as the nature of the specimens, made this one of the most notable exhibits. The first series of slides was produced by an unintentional experiment on living muscle nuclei of the leech *Pontobdella*, and showed important features of nuclear structure. The experiment consisted in injecting corrosive sublimate between the muscle layers of the intestine, instead of into the intestinal cavity, as was intended. The introduction of the cannula caused the nuclei to be compressed at one end and stretched at the other; in this condition they were immediately fixed by the reagent. In the normal nuclei the chromatin is arranged in coarse masses or knots at the angles of the nuclear network. In the stretched nuclei the network gave place to a series of parallel fibrils without cross connections, suggesting those of mitosis, and indicating that the network of the resting nucleus may consist of bundles of interlacing but unbranched fibrils. At the same time the chromatin knots were shown to be collections of granules rather than solid masses, for they had apparently disappeared by becoming evenly distributed along the fibrils. No nuclear membrane was seen, and Professor Apáthy believes that with few exceptions, the better preserved the specimen, the less definite is the nuclear membrane. In smears, nuclei may become distorted somewhat like those exhibited.

The second series of preparations dealt with Krause's membrane, the narrow dark line which bisects the light band of striated muscle fibers. Professor Prenant at one time believed that Krause's membrane occurred only in the muscles of arthropods and vertebrates; later he found it in *Pecten* and *Sagitta* but failed, after repeated attempts, to detect it in *Salpa*. Professor Apáthy demonstrated it very clearly in *Salpa maxima*, and showed it in the coelenterate

*Carmarina hastata*. He believes that it occurs in all striated muscle fibers.

The third series of preparations was of neurofibrillae, which were shown with astonishing clearness. The coarse fibrils of the invertebrate nerve cells (from *Pontobdella* and *Lumbricus*), the finer fibrils of the young dog, and the much finer fibrils of the adult suggest that a subdivision of the fibrils accompanies the perfection of the nervous system. The presence of neurofibrils is, for Professor Apáthy, the essential feature of a nerve cell. All cells have the property of contraction and of conduction, but they are not muscle cells unless they possess myofibrillae, nor nerve cells unless they contain neurofibrillae. It remains to be determined whether the development of neurofibrillae accompanies the outgrowth of processes from the neuroblasts.

Professor R. G. Harrison of Yale University showed drawings of the nerve cell processes sent out by detached cells of the spinal cord of a tadpole. The portion removed was examined in lymph, into which the processes grew, each having at its distal end a group of slender, radiating, amoeboid branches. At times these changed their shape more rapidly than could be drawn. Sections showing similar terminal branches were exhibited. In embryos from which the neural crest had been removed, nerves without sheath cells were produced, thus proving that nerve fibers may grow without the participation of sheath cells, and that the latter are derived chiefly from the neural crest.

Professor H. V. Neal of Knox College, Illinois, showed preparations of embryos of *Squalus*, demonstrating the outgrowth of processes from the neuroblasts. These processes could be traced for some distance through the surrounding tissue which took no part in the formation of the nerve fiber. The specimens showed indications of neurofibrils at an early stage.

Professor A. Maximow of the Imperial Medical Academy of St. Petersburg exhibited preparations of rabbit embryos to show the formation of the blood corpuscles. In the area vasculosa of a rabbit of 8½ days, only one form of corpuscle occurs; it is known as the primitive blood cell, and gives rise both to lymphocytes and to primary erythrocytes. These two forms of corpuscles are all that occur in the wall of the yolk sac at 9½ days. The primary erythrocytes are large cells derived from those which constitute the blood islands. Their formation soon ceases, and they gradually disappear from the circulating blood, in which only few remain at 20 days. Thus they are a purely embryonic type of corpuscle. The lymphocytes likewise

first appear in the yolk sac, but later they are formed from the endothelium of blood vessels within the embryo. A section of the aorta of a rabbit of 10 days and 5 hours showed a rounded mass of lymphocytes projecting into its lumen and still connected with its endothelium. The lymphocytes give rise to other lymphocytes and to the permanent erythrocytes. The latter are smaller than the primary erythrocytes; they are formed from lymphocytes throughout life, and ultimately, by the extrusion of their nuclei, they become the red corpuscles. In the vessels of the yolk sac at 12 days there are three kinds of corpuscles, namely primary erythrocytes, lymphocytes, and permanent erythrocytes. In the mesenchyma around the medullary tube of the embryo of 12 days, two small wandering cells were shown. These cells arise in the mesenchyma; in the bone marrow they come from cells like lymphocytes in the periosteal mesenchyma. The giant cells of the marrow were classed with the lymphocyte series.

In addition to these preparations Professor Maximow showed two others of much interest. One of these was a section of the thymus of a rabbit embryo of 15 days. The solid epithelial masses were being invaded by lymphocytes; the epithelial cells were not becoming deceptively similar to lymphocytes as has recently been stated. The other preparation was from a rabbit's kidney which had become atrophic, following the ligation of the renal vessels. In the kidney calcification and bone formation had occurred, and a well defined macroscopic area of bone marrow had developed. The remarkable development of bone marrow in the kidney always occurred in rabbits, but never in other animals similarly treated.

Mme. W. Dantchakoff of St. Petersburg demonstrated the formation of the blood corpuscles in the chick. A section from an embryo incubated 68 hours, showed cells similar to lymphocytes both within and outside the vessels overlying the yolk. The endothelium seemed to have formed among cells of one sort; those inside the vessels become lymphocytes and red corpuscles, and those outside become polymorphonuclear leucocytes. The differentiation of the cells was shown in a specimen of 104 hours incubation, in which eosinophilic granules were clearly seen in the cells outside of the vessel walls. A distinction between primary and permanent erythrocytes was not established by Dr. Dantchakoff in the chick. Other features, including the proliferation of endothelial cells of the aorta (shown in a specimen of 72 hours incubation), agreed essentially with Professor Maximow's demonstration of the rabbit.

Miss K. Bonnevie, of Christiana, Norway, exhibited preparations

illustrating the nature of heterotypical mitosis and showing that its significance in reduction divisions has been overestimated. Heterotypical chromosomes were demonstrated in the first cleavage division of *Nereis*. In the second maturation division of *Amphiuma* and in the first cleavage of *Thalassema*, cross-shaped chromosomes were shown. Cross-shaped chromosomes or tetrads are therefore not limited in *Thalassema* to the first reduction division. The tetrad shape was shown in some of the chromosomes of *Nereis* in metaphase fifteen hours after fertilization. A longitudinal splitting of the daughter chromosomes was shown in a cleavage mitosis of *Nereis* and also in its second maturation mitosis. Other features of chromosome structure which were demonstrated, include the spiral coiling of chromosomes in *Amphiuma* and *Ascaris*, and a spiral chromatic thread wound around the surface of each chromosome in the root tip of *Allium*. The relation of chromosomes to the resting nucleus was illustrated, and new chromosomes were said to arise within the disseminated chromatic material of the old ones.

Miss A. M. Lutz of Cold Spring Harbor showed sections of the root tips of *Oenothera lamarckiana*, its mutants and hybrids, to demonstrate the variations in the number of somatic chromosomes. The material appears very favorable for the counting of chromosomes, and it was remarkably well preserved and clearly stained. Nevertheless the question of one chromosome more or less in a given count is sometimes very difficult to determine. To the counts which have been made and were demonstrated by Miss Lutz, those recently published by R. R. Gates from somatic cells of the flowers may be added; their counts are as follows,—*Oenothera lamarckiana*, pure bred, 14 chromosomes (14, Gates); *O. nanella*, 14 in some plants, in others probably 15; *O. rubrinervis*, open pollinated, 14; *O. lata*, 14 in one plant, 15 in another (14 with "no indication whatever that the number is ever higher," Gates); *O. gigas*, 28 with a suggestion of a 29th in several instances, but 29 were never demonstrated in pure bred tissue; *O. lata* (hybrid) ♀ × *O. gigas* (pure) ♂ showed 21 in one plant, 22 or 23 in another, and 28 or 29 in a third. In the last case, if each parent supplied one half of its normal number of chromosomes, 21 or 22 should occur in the hybrid and this was observed in two of the plants. In hybrids produced by pollinating *O. lata* with *O. lamarckiana*, Gates has found 20 or 21 chromosomes. From these interesting studies which are still in progress it appears that *O. lamarckiana* and most of its mutants usually possess 14 somatic chromosomes; that *O. gigas* has double that number, suggesting a variety like *Ascaris*

*megaloccephala bivalens*; and that in the hybrids there may be an extraordinary disturbance in the number of chromosomes, the laws and the explanation for which are not apparent.

**Methods and Publications.**—Dr. R. M. Yerkes of Harvard University exhibited apparatus for testing color vision and the delicacy of visual discrimination in mice. Similar boxes are illuminated either by photometered lamps of different intensity or by colored lights. Over the floors of the boxes are wires for an interrupted electric current whereby the animal receives slight shocks when it enters the wrong box. The value of the apparatus is in its complete elimination of sensations other than those which are being tested. Under the title "The dancing mouse; a study in animal behavior," the MacMillan Company has in press a collected account of Dr. Yerkes' investigations of the mental life of a lower mammal.

Mrs. S. P. Gage of Ithaca, New York, showed her method of making models from sheets of blotting paper instead of plates of wax. The outline of the section is drawn upon the paper and may be cut out by the needle punctures from an unthreaded sewing machine. The blotting paper is then soaked in melted paraffin, and the smoothing of the surface, after the model has been put together, is done with paraffin. Pins are inserted, as in wax models, for stability. The resulting model is light and less fragile than those made of wax; it is not liable to change its shape in warm weather, or to crack by the expansion of metal supports.

Professor G. A. Drew of the University of Maine showed a method of making a series of anatomical drawings for reproduction by the zinc process. That part of the animal which is to appear in several drawings is drawn first, and photographed upon suitable paper. The figure is then completed by using pen and ink upon the photograph. Thus the organs may be drawn and photographed, and four figures of the nerves, arteries, veins, and lymphatics respectively may be built up upon this background. Professor Drew used the method in making his drawings of *Pecten*.

Dr. H. H. Field of Zürich exhibited a complete series of the card index to biological literature, issued by the Concilium Bibliographicum. It was shown properly arranged in a library cabinet, and its system was fully explained.

The Department of Comparative Anatomy at the Harvard Medical School exhibited a portion of its collection of 1188 series of vertebrate embryos, sectioned by the paraffin method. This collection may be used at the school by any visiting scientist.

The Secretary of the Universidad Nacional de Buenos Aires sent to the congress numerous photographs of its zoological gardens.

Professor W. B. Scott of Princeton University exhibited Vols. 1, 4, 5, and 8 of the Reports of the Princeton University Expeditions to Patagonia. These volumes, which are all that are now published, are devoted to the general narrative, botany, and paleontology. The entire work is expected to require fifteen volumes, and the expense of publication is met by the "J. P. Morgan Publication Fund." The narrative is said to compare in interest with Darwin's account of the voyage of the Beagle, and it may be printed in brief form for more general distribution.

Dr. H. Przibram of the University of Vienna showed copies of his *Einleitung in die experimentelle Morphologie der Tiere* published by F. Deuticke, Leipzig und Wien, 1904, and the *Experimental-Zoologie, 1, Embryogenese*, published by the same firm in 1907.

Dr. M. C. Piepers sent to the congress a copy of his book *Noch einmal, Mimicry, Selektion, Darwinismus*, published by E. J. Brill, Leiden, 1907. His earlier publication upon the same subject contained the theses which he presented to the Fifth International Zoological Congress, at Berlin, 1901.

**Variation and Mendelism.**—Professor W. Bateson of the University of Cambridge, England, whose address on "Facts limiting the theory of heredity" was of unusual interest, showed the great variation occurring in certain moths, and the results of cross-breeding in pigeons, poultry, and corn. Since this exhibit was not unpacked until the close of the congress, it could not receive the attention which it merited.

Professor T. Dwight of the Harvard Medical School invited the congress to inspect his very fine collection of variations in human bones, displayed in the Warren Museum.

Professor W. E. Castle of Harvard University exhibited live rabbits, guinea pigs, and rats, showing in a most effective way several forms of inheritance. The animals were exhibited in Cambridge, where breeding experiments are still being conducted on an extensive scale. The first series showed color varieties of the domesticated rabbit. The wild gray rabbit bears three independent heredity units,—one for black, one for yellow, and a third for barring (which causes the black and yellow to be disposed in bands upon the individual hairs). The various known color varieties result from the loss or modification of one or more of these three units. The inheritance is Mendelian. The unit composition of each known color variety was explained and in some cases demonstrated by the results of breeding experiments.



It was shown, for example, that in the absence of the barring factor, the black and yellow factors combine to produce three color varieties,—namely pure black, if the black factor is in excess; sooty yellow, if the yellow is in excess; and blue, if the black factor is modified and dilute and the yellow is scanty. Albino animals possess the color factors, but lack an activating substance necessary for pigmentation; the albino form may occur in any of the color varieties.

The second series showed color varieties of the guinea pig. As in the rabbit, the wild coat contains black, yellow, and barring factors which are inherited as independent units. There is also a separable brown factor which in the absence of the black and barring elements produces chocolate colored animals.

The third of the series exhibited was from a race of guinea pigs having four-toed hind feet. The hind feet of the guinea pig, agouti, and capybara are normally three-toed; those of rabbits are four-toed and of mice five-toed. By unremitting selection from the progeny of a single four-toed 'sport,' through five generations, a corresponding race of guinea pigs has become established. The effects of selection upon the color pattern (spots) of guinea pigs and rats were demonstrated, and the last series showed the blended inheritance of ear-length in rabbits. The offspring of a long-eared and a short-eared rabbit have ears of intermediate length, and breed true.

F. T. L.

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## ZOOLOGY

**The Families and Genera of Bats.**— One of the most important recent contributions to the taxonomy of the Chiroptera is "The Families and Genera of Bats," by Gerrit S. Miller, Jr., forming Bulletin 57 of the United States National Museum. It is a volume of about 300 pages, with 14 plates and 49 text cuts, illustrating the dentition, cranial and skeletal characters of this diversified order. The first 12 pages of the introduction are devoted to the technical history of the group, from Linnaeus (1758) to Weber (1904). This is followed by 30 pages on the anatomy of bats, relating especially to the structure of the wing, the shoulder girdle, and teeth, and by a systematic review of the genera and higher groups. The order Chiroptera is divided into the usually recognized two suborders, Megachiroptera and Microchiroptera, the former consisting of the single family Pteropidae,

or Fruit Bats, with 4 subfamilies and 30 genera; the latter containing all the others, which are here distributed among 16 families and 13 subfamilies.

This important monograph is based on the material contained in the U. S. National Museum and other American museums, supplemented by the examination of that contained in the principal museums of Europe, with the result that all but three of the 173 genera here recognized have passed through the hands of the author. The number of "forms" of Chiroptera at present recognized is stated to be about 900; "a number probably representing considerably less than half of what will eventually be known." The designation "forms" probably includes subspecies as well as species.

The systematic part (pp. 43-261) gives the characters of all the higher groups, from order to genus, with the geographic distribution and probable number of forms of each, and diagnostic keys for the suborders, families, subfamilies and genera. The divisions adopted, from families down to genera, are greatly in excess of those recognized by any previous author, but they appear to be all natural groups, subject of course to a different valuation by different authors, according to their points of view. No subgenera are recognized; of the 173 genera characterized, 19 have been proposed by Mr. Miller, only two of which, however, are here first published. For each of the genera a type species is designated, the probable number of species is stated, and those examined by the author are enumerated. The full synonymy is given, not only of the genera but of all the higher groups — a feature of much importance.

In this monograph, the outcome of years of careful investigation, Mr. Miller's usual thoroughness and critical attention to minute details of structure are conspicuously apparent, with the result that naturalists are now provided with an excellent guide through the labyrinths of this large and difficult order of mammals. The text cuts and the first ten plates furnish excellent illustrations, all original, of the dentition and cranial characters of about one third of the genera, thus supplementing in a most important way those contained in previous works, to which, however, direct references are unfortunately wanting. The last four plates illustrate the principal parts of the skeleton in four diverse types — *Rhinopoma microphyllum*, *Diclidurus virgo*, *Noctilio leporinus*, *Molossus pretiosus*.

J. A. A.

**Birds of North and Middle America.**—Mr. Robert Ridgway's "Birds of North and Middle America" is the most important syste-

matic work ever undertaken relating to American ornithology. The original estimate for the work was a series of eight volumes, in octavo, of about 1000 pages each. Its official designation is "Bulletin of the United States National Museum, No. 50." The first volume appeared near the close of the year 1901, and included the single family *Fringilidae*; the second was published in 1902, and covers the four families *Tanagridae*, *Icteridae*, *Coerebidae*, and *Mniotiltidae*; the third bears date 1904, and includes 15 of the remaining families of oscinine *Passeres*; the fourth, published in July of the present year, includes the remaining six families of the *Oscines* and the first four families of the *Mesomyodi*. These families are: *Turdidae*, *Zeledoniidae*, *Mimidae*, *Sturnidae*, *Ploceidae*, *Alaudidae* of the *Oscines*; *Oxyruncidae*, *Tyrannidae*, *Pipridae*, *Cotingidae*, of the *Mesomyodi*. These four volumes include "1675 species and subspecies, or somewhat more than half the total number of North and Middle American birds," or those found north of the Isthmus of Panama, which forms approximately the southern boundary of the area treated. The preparation of Part V is well advanced.

The treatment is entirely technical; definitions are given of all the higher groups, with keys to the minor divisions, and in the case of genera to the species and subspecies. The latter are described in detail, with a concise statement of their geographic ranges, followed by full (often annotated) bibliographic tables, which often frequently occupy the larger part of the text. But there is nothing relating to their life histories beyond, in some instance, a brief reference under the generic headings to the nest and eggs. The work is, however, invaluable to the systematist, and will ever remain a monument to the industry and painstaking accuracy of its author, and it will be long before its usefulness will be superseded by any subsequent work.

J. A. A.

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## BOTANY

**Floral Ecology.**—In the writings of Darwin and his contemporaries the structure and environmental relations of flowers hold a prominent place. This is only natural when we remember that the Darwinian theory is essentially a theory of adaptation. For a considerable time it seemed that interest in floral adaptations was lagging, but this kind of work is again being quite generally taken up. Possibly a reason for

the renewal of interest is to be seen in the completion of Knuth's Handbuch, and certainly the popularity of this kind of investigation is attested by the promise of a complete translation of this large work from the Oxford press.

It is not surprising that the Italians, who until very recently have had Delpino—a pioneer in this field—among them, should show especial activity in studies of floral ecology. The Orto Botanico della R. Università di Napoli is now commencing the republication (Bull. Orto Bot. R. Univ. Napoli 2:3-65. 1904) of a portion of Delpino's Ulteriori Osservazioni which first appeared in 1873-'74. This is unquestionably one of the most important treatises on floral ecology and its republication will be welcomed by many to whom the original is not accessible. Delpino's elaborate classification was proposed at a time when there was not a broad basis of observation but the conception is certainly worthy of the most careful consideration and one of the chief problems before future workers in this field is to determine in how far floral adaptations may be thrown into real categories such as Delpino suggests. This is to be one of the crucial tests of adaptation which we need at the present stage of development of the evolution theory.

Before passing from the work of Delpino, it may not be out of place to mention that an appreciation of the man and a bibliography of his writings has just been published by Briosi (Atti Ist. Bot. Univ. Pavia II. 10: vi-xxi. 1907). Over one hundred and twenty titles are given, a large proportion of them being on various phases of vegetable ecology.

The fifth memoir of Scotti's series on the floral biology of the "Personatae" may be mentioned as another large undertaking. This number (Annali di Botanici 5:101-227. 1907) comprises the families Solanaceae, Scrophulariaceae, Bignoniaceae, Martyniaceae, Pedaliaceae, Orobanchaceae, Gesneriaceae, Lentibulariaceae, Globulariaceae and Acanthaceae. The work is largely a review of the literature on the floral ecology of these groups but it serves a useful purpose in bringing together in one place a detailed discussion of a large body of widely scattered observations.

Mattei (Bull. Orto Bot. R. Univ. Napoli 2:115-117. 1904) gives lists of visitors of *Dracunculus vulgaris*. Nicotra (Bull. Soc. Bot. Ital. 1906:128-131) discusses the floral ecology of Urtica, Agave and Smilax. Graenicher has published two papers (Bull. Nat. Hist. Soc. Wisc. n. s. 5: 15-45, 84-95. 1907) on the pollination of Wisconsin flowers. In these the families Melanthaceae, Liliaceae, Convallariaceae, Saxifragaceae, and Grossulariaceae are considered. The obser-

uations are very similar to those made by Müller and MacLeod in Europe and by Robertson in our own country and it is to be hoped that the author will continue the work with vigor.

Burck has been engaged in studies of anther dehiscence and concludes (Proc. Kon. Akad. Amsterdam 1906: 390-396, and Rev. Gén. Bot. 19: 104-111. 1905) that the opening of the anther is effected by the withdrawal of water from the anther by sugar contained in the filament. This permits the dehiscence of the anther in an atmosphere saturated with moisture.

Harms (Ber. Deutsch. Bot. Ges. 25: 165-176. 1907) has investigated cleistogamy in three species of the genus *Clitoria*. The studies were made on herbarium material. The author concludes that we are here dealing with a real cleistogamy in the sense in which Göbel uses the term. The characteristics of the cleistogamous flowers are the small size of the calyx, the absence of the corolla and a more or less pronounced reduction in the androecium.

Tuzson (Bot. Jahrb. 40: 1-14. 1907) has observed cleistogamy in *Robinia pseudacacia*. Two trees were found together in the same row of old trees along a street and he thinks it probable that one was derived from the other by vegetative reproduction. The individuals were about thirty to forty years old and have been under observation since 1902; since then they have flowered in 1904 and 1906. Fertilization occurs exceedingly rarely. In these forms cleistogamy must be considered a highly disadvantageous characteristic which originated discontinuously and which would be eliminated in the struggle for existence. The author does not agree with all of Göbel's views on cleistogamy but insists on the causal rather than the teleological attitude in the investigation of the problem.

Dop (Bull. Soc. Bot. Fr. IV. 7: 258-260. 1907) again discusses the mechanism of movement in the stamens of the Berberidaceae.

Fritsch (Verh. K. K. Zool.-Bot. Ges. Wien 56: 135-160. 1906) publishes list of insect visitors for about 150 species of the flora of Steiermark. The observations were made in 1904.

J. ARTHUR HARRIS.

## PUBLICATIONS RECEIVED

From August 1 to September 1, regular exchanges are not included  
The year of publication, when not otherwise noted is 1907

HOUGH, T., AND SEDGWICK, W. T. *Elements of Physiology*. Boston, Ginn & Co., 1907. 12mo, 321 pp., illus. \$1.25.—NEWMAN, H. *Laboratory Exercises in Elementary Physics*. Boston, Ginn & Co., 1907. In four parts. \$1.50 per dozen.

ALLEN, W. F. Distribution of the subcutaneous vessels in the head region of the Ganoids, Polyodon and Lepisosteus. *Proc. Washington Acad. Sci.*, vol. 9, pp. 79-158, pls. 1-15.—COOK, O. F. Mendelism and other methods of descent. *Proc. Washington Acad. Sci.*, vol. 9, pp. 189-240.—COOK, O. F. Origin and evolution of angiosperms through apospory. *Proc. Washington Acad. Sci.*, vol. 9, pp. 159-178.—DALL, W. H. Linnaeus as a zoologist. *Proc. Washington Acad. Sci.*, vol. 9, pp. 272-274.—DAVENPORT, C. B. Heredity and Mendel's law. *Proc. Washington Acad. Sci.*, vol. 9, pp. 179-188.—FELT, E. P. White marked tussock moth and elm leaf beetle. *N. Y. State Mus.*, bull. 109, 31 pp., 8 pls.—GREENE, E. L. Linnaean memorial address. *Proc. Washington Acad. Sci.*, vol. 9, pp. 241-271.—MANN, A. Report on the diatoms of the Albatross voyages in the Pacific Ocean, 1888-1904. *Cont. U. S. Nat. Herbarium*, vol. 9, pt. 5, pp. 221-442, pls. 44-54.—Mc BAIN, J. W. The experimental data of the quantitative measurements of electrolytic migration. *Proc. Washington Acad. Sci.*, vol. 9, pp. 1-78.—MEEK, S. E. Synopsis of the fishes of the Great Lakes of Nicaragua. *Field Columbian Mus.*, zool. ser., vol. 7, no. 4, pp. 97-132.—MERRILL, G. P. Catalogue of the type and figured specimens of fossils, minerals, rocks, and ores. *Bull. U. S. Nat. Mus.*, no. 53, pt. 2, 370 pp.—MILLER, G. S. The families and genera of bats. *U. S. Nat. Mus.*, bull. 57, 282 pp., 14 pls.—RIDGWAY, R. The birds of North and Middle America, part IV. *Bull. U. S. Nat. Mus.*, no. 50, 973 pp., 34 pls.—STEJNEGER, L. Herpetology of Japan and adjacent territory. *U. S. Nat. Mus.*, bull. 58, 577 pp., 35 pls., 409 figs.—WHEELER, H. J. AND ADAMS, G. E. Continued test of nine different phosphates upon limed and unlimed land with several varieties of plants. *R. I. Agric. Exp. Sta.*, bull. 118, pp. 55-86.—WHEELER, H. J., HARTWELL, B. L., MORGAN, J. F., AND PURRINGTON, W. F. Analyses of commercial feeding-stuffs. *R. I. Agric. Exp. Sta.*, bull. 119, pp. 89-107.

ANNALS OF THE QUEENSLAND MUSEUM, no. 7.—NEW YORK STATE MUSEUM. REPORT ON INJURIOUS AND OTHER INSECTS.—PROCEEDINGS OF THE LINNEAN SOCIETY OF NEW SOUTH WALES FOR 1907, part I.—ABSTRACT OF PROCEEDINGS OF THE LINNEAN SOCIETY OF NEW SOUTH WALES, June 26th, 1907.

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